VOL. XI OCTOBER 1957 NO. 4

PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

IN THIS ISSUE: Moore — *Species of* Xeronema • Wentworth — *Impact Scars at Kilauea* • Iversen and Yoshida — *Biology of Wahoo in the Line Islands* • Matthews — *Anomuran Non-pedunculate Spermatophores* • Marples — *Spiders from Pacific Islands, II* • Newell — *Studies on the Johnstonianidae* • Index

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(Continued on inside back cover)

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PACIFIC SCIENCE is published quarterly by the University of Hawaii Press, in January, April, July, and October. Subscription price is $3.00 a year; single copies are $1.00. Check or money order payable to University of Hawaii should be sent to University of Hawaii Press, Honolulu 14, Hawaii, U.S.A.

The Species of *Xeronema* (Liliaceae)

LUCY B. MOORE[1]

BRONGNIART AND GRIS (1864*a*) proposed the genus *Scleronema* to accommodate a species which they named *S. moorii* in honour of Mr. C. Moore, Director of the Botanic Gardens in Sydney, who had collected specimens from the mountains of New Caledonia. The name *Scleronema* was preoccupied (Bentham, 1862: 109) and within a few months Brongniart and Gris (1864*b*) substituted the name *Xeronema* and the New Caledonian plant became *X. moorii* (spelled *moorei* by later authors). A full and illustrated description of this species appeared four years later (Brongniart and Gris, 1868: 2–5, table 1), together with a discussion of its affinities. The genus *Xeronema* was considered monotypic until the discovery of *X. callistemon* on cliffs of the Poor Knights Islands off the east coast of North Auckland, New Zealand (Oliver, 1925: 383, 1926: 1–3). In 1933 Mr. A. T. Pycroft found the new species on Taranga or Hen Island, some 30 miles farther south (Cranwell, 1933: 234–36). Figure 1 shows the geography of these locations.

In drawing up his description of *X. callistemon* Oliver had at his disposal Brongniart and Gris's 1868 account and figures of *X. moorei* but no direct comparison of specimens of the two species seems to have been made until recently. In August 1953 Mr. L. J. Dumbleton, then of the South Pacific Commission in New Caledonia, kindly sent early and mature flowering stems collected from an altitude of 600 to 750 metres on Mont Mou, followed in June 1954 by a rooted fan and a head of mature capsules still containing a few seeds, collected from an altitude of 1,000 metres on Montagne des Sources on the main mountain chain near Noumea. These specimens confirm that the two species are amply distinct though undoubtedly congeneric, but there are good distinguishing characters other than those emphasized by Oliver. It seems worth while to review the differences and at the same time to record some further details about the New Zealand species.

[1] Botany Division, Department of Scientific and Industrial Research, Wellington, New Zealand. Manuscript received August 10, 1956.

ACKNOWLEDGEMENTS

The writer gladly expresses thanks to Mr. L. J. Dumbleton for the New Caledonian material on which comparisons were based; to Dr. W. R. B. Oliver for a copy of Brongniart and Gris's 1868 paper and figure and for other help; to Miss E. K. Pickmere (Mrs. W. Reynolds) for careful notes on garden plants; to Miss N. M. Adams for the drawings for Figure 4.

COMPARISON OF THE TWO SPECIES

The two species resemble each other in habit, with stiff iris-like bright green leaves borne in many short-stemmed fans (Figs. 2, 3). Leaf bases are very fleshy, making the plants drought-resistant, and in both species there is a distinct sinus just above the junction of sheath and blade; this sinus is not shown in Brongniart and Gris's figure and Oliver erroneously listed it amongst distinguishing characters of *X. callistemon*. The stout scape with its sheathing bracts carries the horizontal raceme well above the leaves. Flowers arise in the axils of bracts all round the raceme axis, but the pedicels of those on the under side elongate and bend upwards so that they are "toutes dirigées vers le ciel." The inflorescences seen show the same colour range in both species, being predominantly and persistently red (the pollen almost tangerine), with gradual change from bright to duller

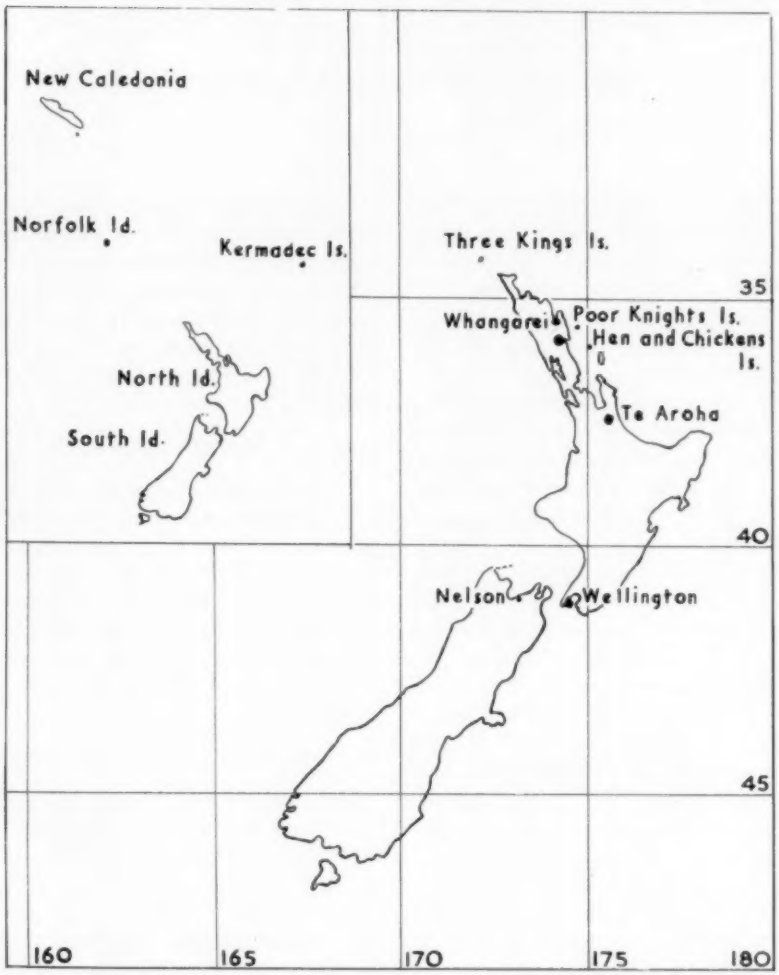


FIG. 1. Map of New Zealand showing places mentioned in text. Inset indicates position of New Caledonia in relation to New Zealand.

tones as the capsules ripen. *X. callistemon* shows a wide diversity in size, leaves reaching more than a metre and racemes up to 30 cm. in length; on the other hand plants 30 cm. tall can bear racemes only 10 cm. long both on exposed ridges on the islands and under comparable garden conditions. Dimensions given for *X. moorei* are nearer this minimum but it is uncertain whether the difference in size is at all significant; as a matter of convenience smallish plants and inflorescences might have been chosen for sending to herbaria. Thus vegetatively the two species would be difficult to distinguish from each other, and the flowering heads are much alike in general appearance.

Floral structures show good diagnostic characters. As Oliver pointed out, the tepals of the inner whorl in *X. callistemon* are narrower than the outer ones, whereas in *X.*

moorei they are all similar (Fig. 4A, D). Differences in capsule shape were emphasized by Oliver and are shown in Figure 4B, E; New Zealand capsules are more strongly stipitate than those seen from New Caledonia. A striking difference not recorded by Oliver, since it was not suggested by Brongniart and Gris, either in description or figure, is seen in the old capsules. In *X. moorei* the style remains slender and becomes twisted like the long staminal filaments which, together with the shrivelled persistent tepals, form a thready tangle about the opened capsule.[2] In *X. callistemon* the style thickens and dries firm and straight and stiffly erect so that the raceme permanently retains its brush-like appearance (Fig. 4B, E, Fig. 5). In both species the spreading of the capsule valves at dehiscence tends to split the style base into its three constituent parts, with frequent breakage in *X. moorei*.

Brongniart and Gris (1868: 3) describe fertile seeds of *X. moorei* as 1.5 mm. long, "uno latere convexa, aculeis brevibus apice inflatis truncatisque exasperata, altero nudo lateraliter raphe carinato." This description and their accompanying figures agree rather well with seeds of *X. callistemon*. Seeds from the capsules recently received from New Caledonia (Fig. 4F) are regularly longer than those of *X. callistemon* and almost oblong in outline; processes cover the surface except on rather vaguely defined furrows at the sides of the prominent keel which is itself echinate along its ridge. In *X. callistemon* (Fig. 4C) the seeds taper somewhat towards one end, the keel is smooth and the inner faces are plane and sharply distinct from the outer curved face which alone is echinate with semitransparent blunt cylindrical processes; processes in *X. moorei* are equally blunt but darker, more opaque and more inclined to be bent.

[2] "Les filets staminaux longs, secs et persistants du *Xeronema*, même a l'époque de la maturité du fruit, lui donnent un aspect tout particulier d'où nous avons tiré le nom générique" (Brongniart and Gris, 1868: 5). Compare the erroneous explanation in Cranwell and Moore, 1938: 25 and Moore, 1953: 26.

FIG. 2. *X. moorei*. Montagne des Sources, New Caledonia; on top of rocky ridge. 1955. Photograph by L. J. Dumbleton.

The pollen of *X. callistemon* has been described and figured (Cranwell, 1942: 293; 1953: 49, pl. 5, text fig. 38). That of *X. moorei* is slightly smaller but with similar exceedingly characteristic reticulation of the exine (Cranwell, 1953, from herbarium specimen, confirmed by N. T. Moar (personal communication) from fresh pollen).[3]

ECOLOGY AND DISTRIBUTION

The habitats of the two species are probably as nearly alike as their different latitudes can provide. *X. moorei* in New Caledonia (Lat. 22° S) "seems to do best on rather rocky narrow ridges more or less in the cloud belt" (Dumbleton, in litt.). Selling (in Guillaumin,

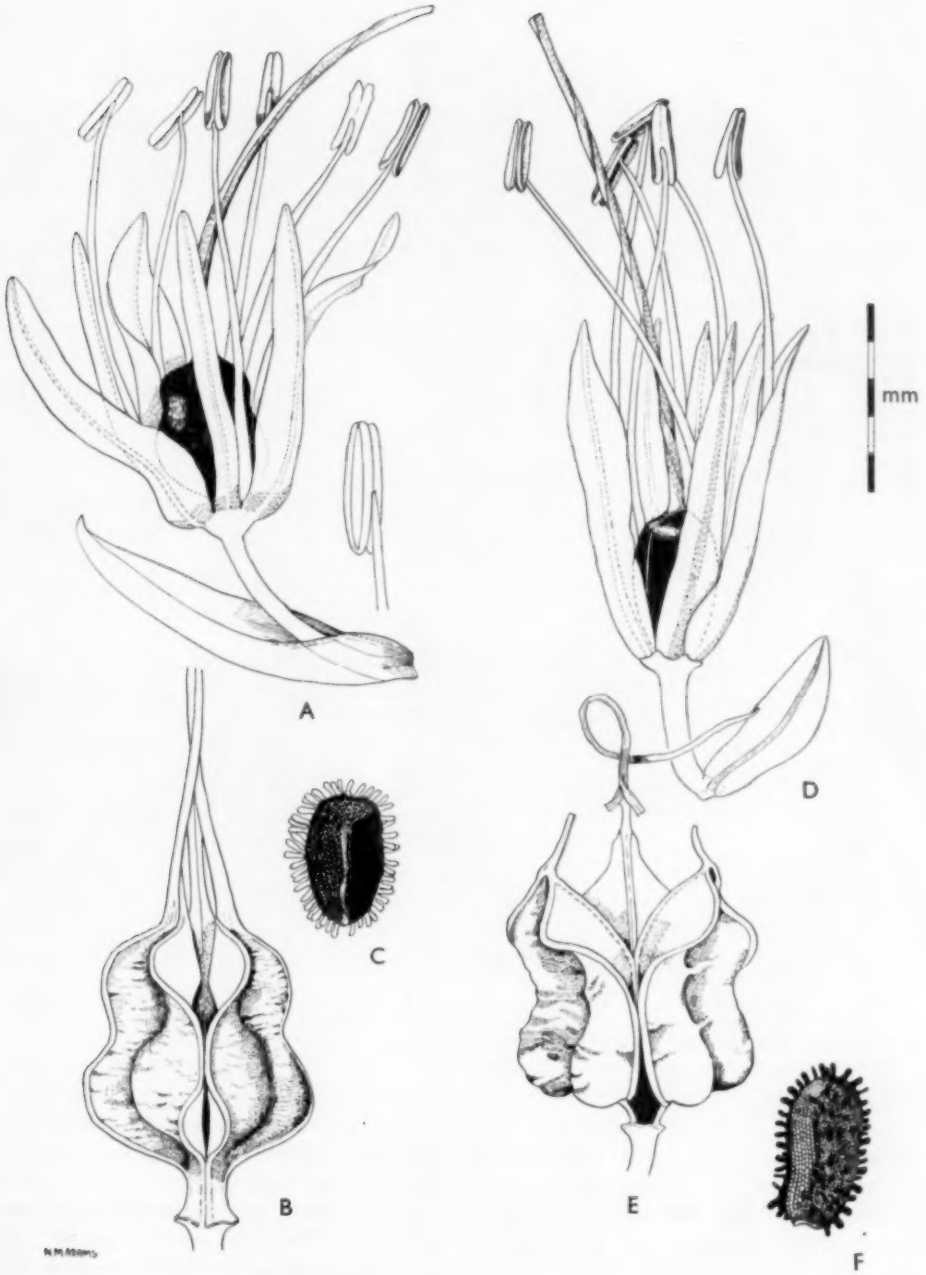
[3] Chromosome numbers of *Xeronema* have been counted by Dr. J. A. Rattenbury of Auckland University College. *X. moorei* from Montagne des Sources has a somatic number of 2n = 72 (unpublished) and *X. callistemon* from Hen Island a somatic number of 2n = 36 (*Roy. Soc. New Zeal. Trans.* (1957) 84 (4)). Specimens from which root tips preparations were made are growing at Auckland University College.

FIG. 3. *X. callistemon*. Hen Island, New Zealand; on cliff edge, sea in background. 1933. (*Arthropodium cirratum* in foreground.) Photograph by L. M. Cranwell.

1925: 13) records it from "Montagne des Sources, *Araucaria Muelleri*-forest, 800 m., not uncommon"; his photograph (*loc. cit.* Fig. 8) shows this as a rather open forest where much light reaches the rocky floor. K. H. Marshall (1954: 21) mentions, above the "clouds" forest, "a small natural clearing of about one square chain, at 5,000 feet, just crammed full of xeronema in full bloom."

On the New Zealand offshore islands good drainage and plenty of light seem essentail for *X. callistemon*, as on ledges and tops of cliffs to an altitude of 300 metres, and, on the northern island of the Poor Knights, on flat ground where rhyolitic soil is "very poor, dry and inhospitable" (Cranwell, 1937: 104, pl. 26). Seedlings are established only in well-lit places. On cliff faces plants that have accumulated great masses of leaf-debris not infrequently break off. Those that fall to the floor of rather dense forest do not long survive in the shade there. Some tumble into the sea and such a clump was found washed up on one of the Chickens Islands where the species is not known to grow (Cranwell and Moore, 1935: 309); it is quite unlikely that the sea could ever lift a whole plant to a place where it could establish afresh and so extend

FIG. 4. A–C: *X. callistemon*. A, flower from middle of raceme, garden-grown by Mrs. A. R. Pickmere (BD 50094A); B, capsule, garden-grown by Dr. W. R. B. Oliver; C, seed, Poor Knights Island, keel view: pale processes confined to outer rounded surface and seen only peripherally, keel and inner faces smooth. D–F: *X. moorei*. D, flower from middle of raceme, Mont Mou (BD 83585B); E, capsule, Montagne des Sources (BD 87634); F, seed, Montagne des Sources, lateral view showing dark processes on rounded outer surface to right and on keel to left. Scale applies to flowers and capsules; seeds drawn twice as large; enlarged anther shows filament inserted in pit between anther lobes. Drawings by Nancy M. Adams.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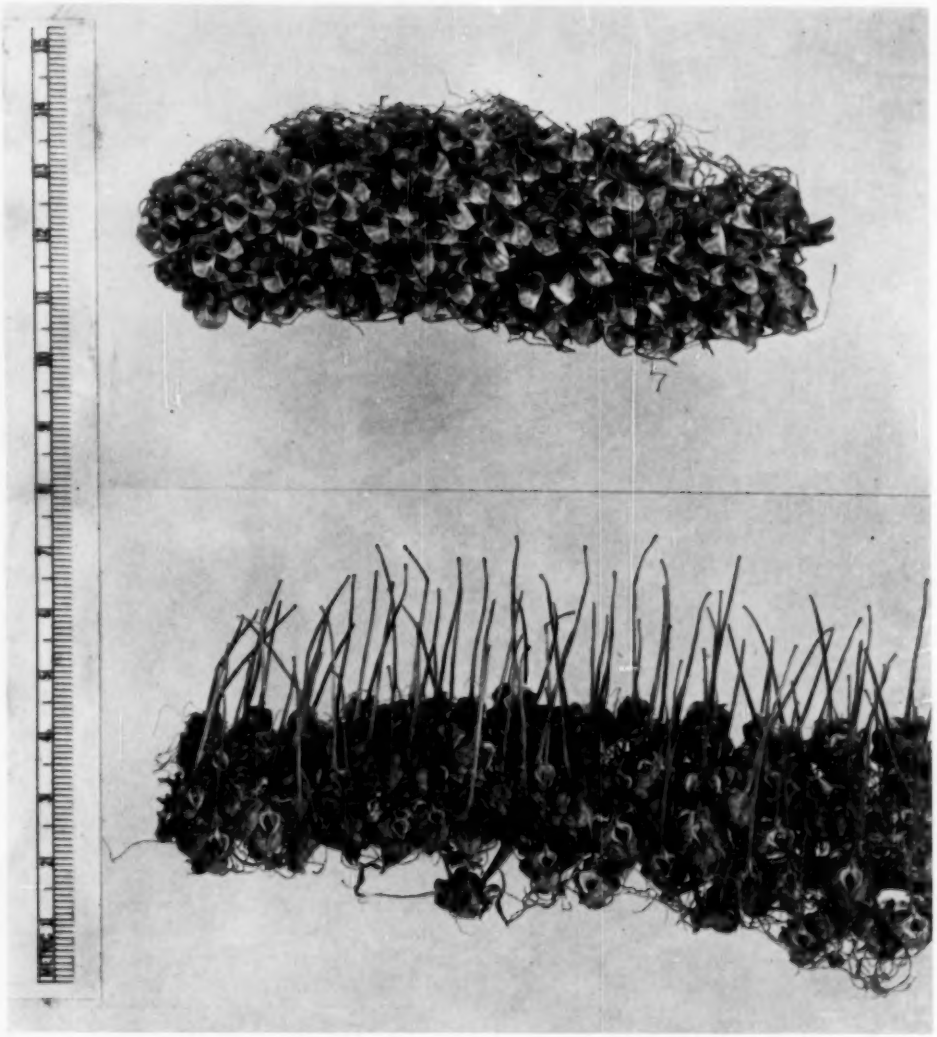

FIG. 5. Racemes with dehisced capsules. Above, *X. moorei*, Montagne des Sources, whole raceme, styles twisted and tangled with dry threadlike tepals and stamens; below, *X. callistemon*, garden-grown by Dr. Oliver, portion of raceme only, styles stiff and erect. Photograph by S. N. Beatus.

the range of the species.

Except that seeds drop easily into rock crevices at lower levels, neither species has an efficient dispersal mechanism. Of the numerous seeds in each capsule many fail to mature, some are shaken out, and some escape only when the capsule finally disintegrates.

X. moorei is known only from New Caledonia. *X. callistemon* has been found on two of the many island groups off the North Auckland coast, but not on islands between these two. The same sort of "spotty" distribution is shown by *Meryta sinclairii* (also

with affinities with New Caledonia) growing on Hen and Chickens and Three Kings Islands but not on Poor Knights and other intermediate groups. The recent discoveries on Three Kings of *Plectomirtha baylisiana* (Anacardiaceae) and *Tecomanthe speciosa* (Bignoniaceae) (Oliver, 1948: 224, 233), representing families not otherwise known in the New Zealand flora, and of the new genus *Elingamita* (Myrsinaceae) (Baylis, 1951: 99–102), illustrate also how important these offshore islands are from the point of view of plant geography. The cliff habitat of *X. callistemon* should save it from fire which is the worst menace to these significant but vulnerable vegetation remnants.

ADDITIONAL NOTES ON *X. callistemon*

Cockayne (1928: 73) places *X. callistemon* in the highest class from a horticultural standpoint. Although it is not yet listed by nurserymen it is grown in many gardens and has flowered as far south as Nelson. At the Royal Botanic Gardens, Kew, plants had been established by 1938 and the species flowered there for the first time in 1953. Garden plants have provided useful supplementary information about this rare species.

In Hatea Street, Whangarei (30 miles south of the Poor Knights Islands), at the home of the late Mrs. A. R. Pickmere, *X. callistemon* has been grown in pots and in open ground since 1924, flowering first in 1932, and the original plants are still thriving in 1956. These plants set good seed and some details of germination and growth rate have been recorded from them (Cranwell and Moore, 1938: 27). A seedling from the first flowering has bloomed at Te Aroha at the age of 22 years. Dr. W. R. B. Oliver has a plant in a sandy coastal garden at Seatoun, Wellington, North Island, brought from Poor Knights in 1933 by Cranwell and Moore; this has produced flowers regularly since 1942, with a maximum number of 16 inflorescences in 1951 and a total in nine recorded years of 48 flower heads. Seeds from this plant have been successfully germinated.

Miss E. K. Pickmere pointed out in 1942 (in litt.) that amongst plants from Poor Knights Islands two distinct forms can be recognized at flowering, and particularly at bud stage, though vegetatively all are alike. The difference lies in the floral bracts which in most of the plants under observation in the garden are definitely longer than the pedicel, exceeding the bud length, and are green at the time the flowers open (Fig. 4A, of BD 50094A[4]); in other plants, as in Dr. Oliver's (and in *X. moorei*), the bracts are barely as long as the pedicels and are red and scarious from the beginning (e.g., BD 50094B). In two plants, both from the southern island of Poor Knights and growing in one pot, bracts were measured in 1943; larger bracts on basal, middle and upper flowers were 4.5, 1.5, and 0.7 cm. long while smaller ones were 1.3, 1, and 0.5 cm. long respectively. The difference has been maintained in these garden plants over many years and in the one case where flowers of a seedling have been compared with those of its parent both are short-bracted. Two published colour pictures of this species suggest the difference though neither does the plant full justice. In a painting of a partly opened inflorescence (Laing and Blackwell, 1940, unnumbered) the longer green bracts are perhaps overemphasized; a colour photograph (N. Z. Gardener, 1954, Colour Supplement) shows a raceme at the stage where bracts begin to wither, but this appears to be of the short-bracted kind.

Garden plants have also provided material for an anatomical study (Mueller, 1928) of root, stem, and leaf. The cytological and embryological work required to make a detailed comparison between this genus and others in the subfamily Asphodeloideae (Cave, 1953: 142) awaits attention.

SUMMARY

Fresh material of *X. moorei* Brong. et Gris

[4] Number in the Herbarium of the Botany Division, D.S.I.R., New Zealand.

from New Caledonia has been compared with *X. callistemon* W. R. B. Oliver of New Zealand. Differences in perianth members and in form of fruit mentioned by Oliver are confirmed, but the sinus on the inner edge of the leaf is well-developed in both species and is not a distinguishing character. Hitherto-unmentioned differences are that the style at fruiting stage is thin and irregularly twisted in *X. moorei*, stout and stiffly erect in *X. callistemon;* in seeds of *X. moorei* the keel is echinate, in *X. callistemon* keel and well-defined inner faces are without processes. The montane habitat of *X. moorei* in New Caledonia is probably similar in some respects to the coastal cliffs of New Zealand offshore islands where *X. callistemon* grows. No morphological feature of either species suggests an explanation for the peculiar distribution of the genus, and of the New Zealand species. Garden plants provide supplementary information about *X. callistemon*, and in particular indicate that two forms may be differentiated on characters of the floral bracts.

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Impact Scars at Kilauea[1]

CHESTER K. WENTWORTH[2]

KILAUEA CALDERA is an ellipsoidal area about two by three miles in extent, whose floor around its eastern, northern, and northwestern margins stands 200 to 500 feet below the surrounding surface of Kilauea volcano. At the southwest the caldera is open at grade and any copious lava flow would pass out and down the south slope of the volcano. The floor of the caldera is a low basaltic shield which at its apex, around Halemaumau, stands more than 200 feet above the lower parts of the northeast margin.

Halemaumau, the so-called firepit, is at present somewhat more than 3,000 feet in diameter, and its floor, at about 450 feet below the rim, consists of the surface of the 1954 lava flow, with a few protruding cone remnants from the more bulky 1952 flow. The floor of the caldera to the north, east, and northeast of Halemaumau consists of pahoehoe lava flows marked by tumuli and other characteristic features. Parts of the area to the west and south show the fresh surface of the 1921 lava flow, but more of the area to the south and west is mantled by ash beds and by thin layers and surface windrows of pumice. Surrounding Halemaumau, which was enlarged greatly by phreatic explosions in 1924, the surface of the caldera floor is strewn with blocks thrown out at that time and ranging up to several feet in diameter. On the eastern side, where the blocks landed on bare lava flows, in many instances the blocks broke through the surface lava layers into blister or other cavities beneath. Some remained in the holes and others ricocheted beyond, commonly showing their origin from the direction of the firepit. On the western side, the ash layers were thicker and offered more cushioning; here there are a few impact craters where blocks fell, but these are not as conspicuous as those of another older series which are to be described in this paper. The limits to which blocks of the 1924 explosive eruption were thrown are easily seen in the field. The holes in the lava are shown in Figure 1.

The caldera margin, from the east side around to the north and west and to the southwest of Halemaumau, is a rock cliff in which the lava flow section is clearly exposed. The southeast and south margin falls in an area where ash layers from successive eruptions amount to 30 or more feet in thickness. Along this line the surface faulting is compound and the ash section shows several parallel cracks with displacement along some. The hard rock margin is exposed in only a few places. To the south and southwest, the margin of the caldera is outlined by a rolling, sand-covered surface, with lava rock a few feet down, but exposed only in gullies that notch the margin.

[1] Publication authorized by U. S. Geological Survey. Manuscript received July 2, 1956.

[2] Hawaii National Park, Hawaii.

FIG. 1. A hole in the crust of the pahoehoe formed by the block shown, flung from the pit of Halemaumau by phreatic explosion in 1924.

Southeastward from Halemaumau, after passing the area of the 1924 blocks and coming onto the ash terrane between the tourist parking field and Keanakakoi Crater, there is revealed an area marked by numerous circular scars. This area, outlined on Figure 2, is strewn with blocks, ranging to several feet in diameter. It extends across the several linear terraces and crack scars leading up to the smooth upland southwest of Keanakakoi Crater and several hundred feet beyond before the blocks and the circular scars come to an end. An area of the scars runs north of the road, toward the west being practically on the level filled by the Kilauea lavas, then they are found on the higher level to the east and continue to beyond Keanakakoi. The principal area is south of the road, running southward toward the principal rim bluff, here marked by ash. The scars continue beyond the bluff however and are found on the upper sandy plateau to the southward (Fig. 2).

The gritty, block-strewn surface carries a scanty vegetation, consisting of a few small ohia trees (*Metrosideros polymorpha*) 6 or 8 feet high, scattered shrubs of pukeawe (*Styphelia Tameiameiae*), ohelo (*Vaccinium reticulatum*), and kupaoa (*Railliardia* sp.), a few small, isolated ferns, sedges, and grasses, a native *Portulaca* species, and kukae nene (*Coprosma ernodeoides*).

The impact scars are outlined by rings, generally 2 to 12 feet in diameter (Fig. 3). A few are as much as 20 feet across. The rings consist in part of coarser fragments ranging up to 6- or 8-inch blocks and are conspicuous because of the lag effect whereby associated finer material has been blown and washed away. Within each ring is a central depression a few inches to one or two feet deep, with a surface of finer silt which has washed in from the surrounding ring (Fig. 4). In many of the rings the silt of the central depression has a slightly cemented crust due to drying out of capillary moisture, in common with most of the surface of the ash terrane. The general appearance of the rings, where they are closely spaced, resembles polygonboden, but the similarity is certainly superficial and is due to lag processes rather than to frost (Fig. 5).

The larger rings often retain the blocks that apparently caused them, or the block responsible can often be identified with confidence a few feet beyond (Figs. 6 and 7). There is a preponderance of indicated flight directions stemming from the vicinity, roughly, of the present Halemaumau. Some of the blocks have broken on landing, as also have some of those of the 1924 series.

Many of the rings are marked by one or more small trees or shrubs which have taken

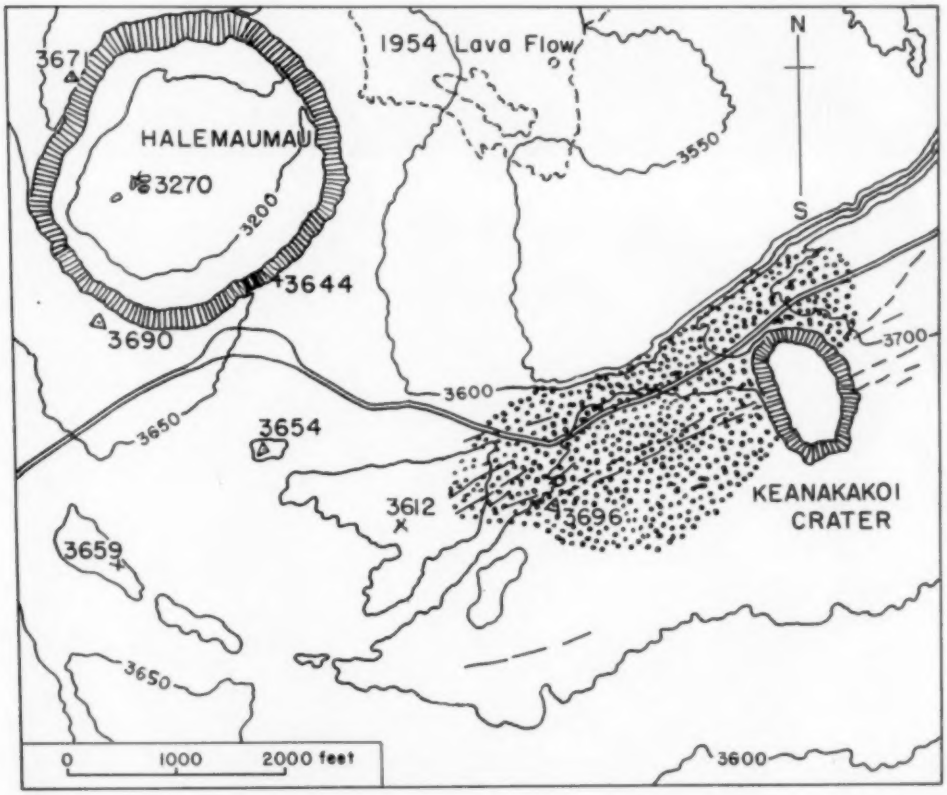

FIG. 2. Sketch map showing the southern part of the caldera of Kileauea and distribution (stippled area) of the impact scars here described.

FIG. 3. Scar with small stone within. Scar about 7 feet across.

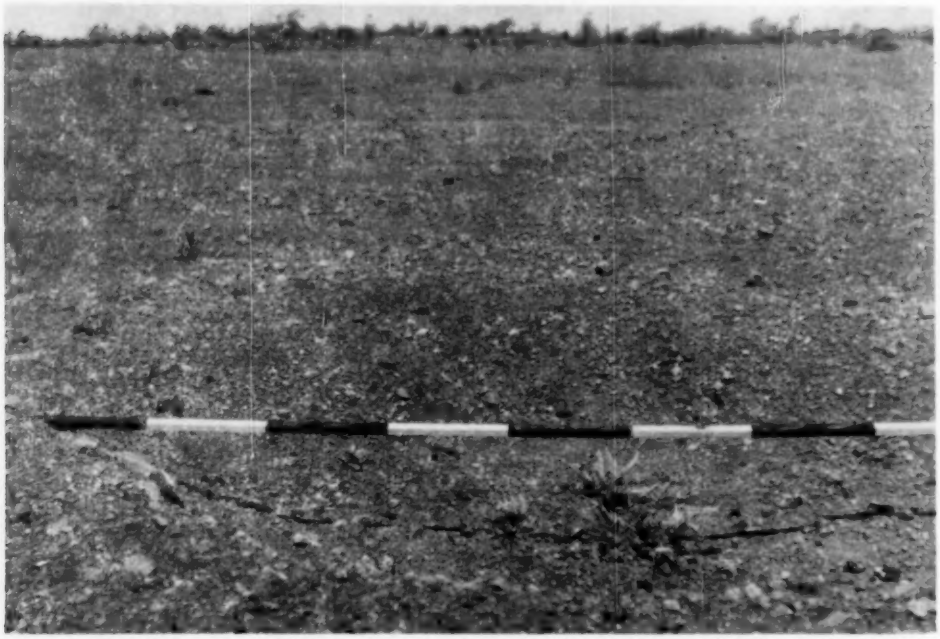

FIG. 4. Scar with pole laid across to show depth. (Pole is marked in one-foot divisions.)

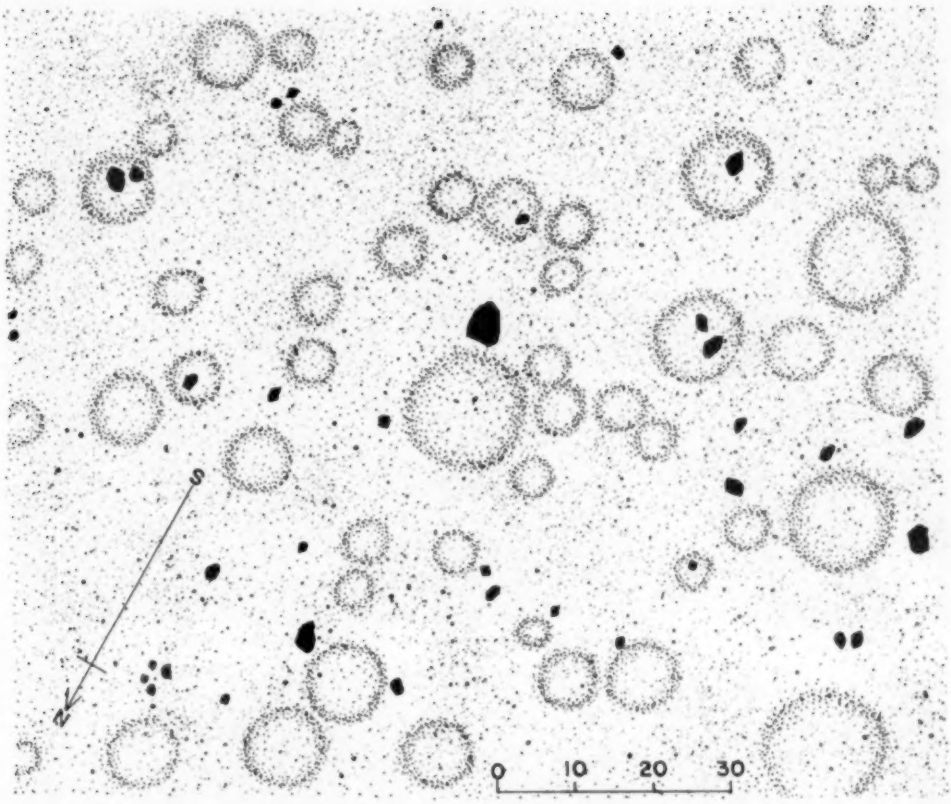

FIG. 5. Pattern of area where the scars are thickest, sketched by rope survey. The large black spots are by actual survey of size and position; smaller pattern of rings is by survey but dots are symbolic.

root in the finer soil of the center portion, or in the shelter of the block which remains. Other vegetation also is somewhat adapted to the ring pattern.

It can reasonably be supposed that this outer series of scars was formed in the 1790 eruption. If they had been formed earlier they would likely have been destroyed by the ash flung out by that eruption. However, there is no contemporary record and we are left with this very general evidence and presumption. That eruption was very violent and threw out much accidental material.

The rims are by no means covered by coarse blocks, and at midday the whole pattern is fairly faint, though discernible by a person who looks for it. At sunrise and in late afternoon the rings are most conspicuous from their relative relief. In the central part of their distribution the rings occur perhaps in every 20-foot square of the ground; around the margin of the area they are scarcer, perhaps two or three in an acre.

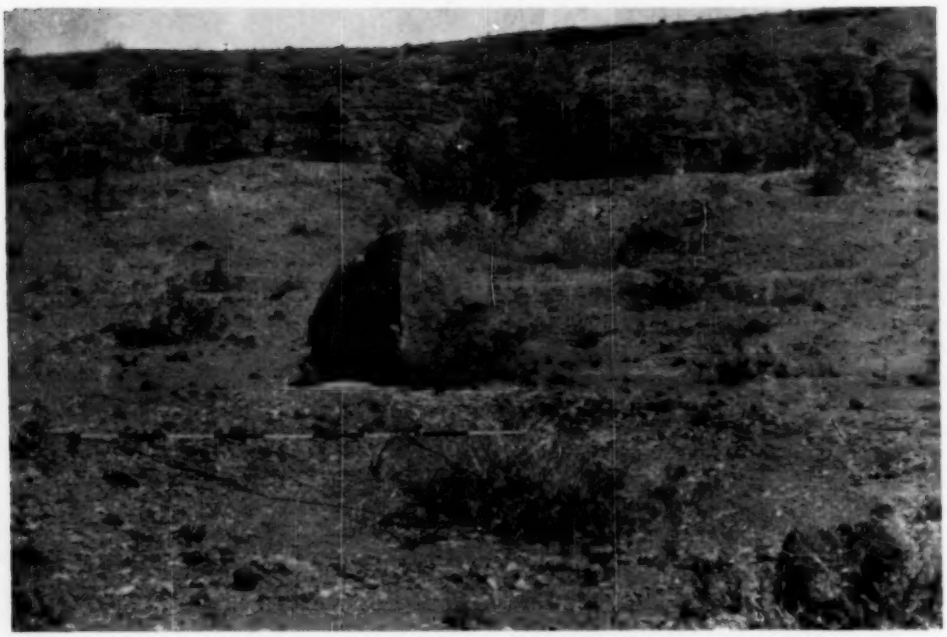

FIG. 6. Ring with pole showing depth and with responsible block beyond.

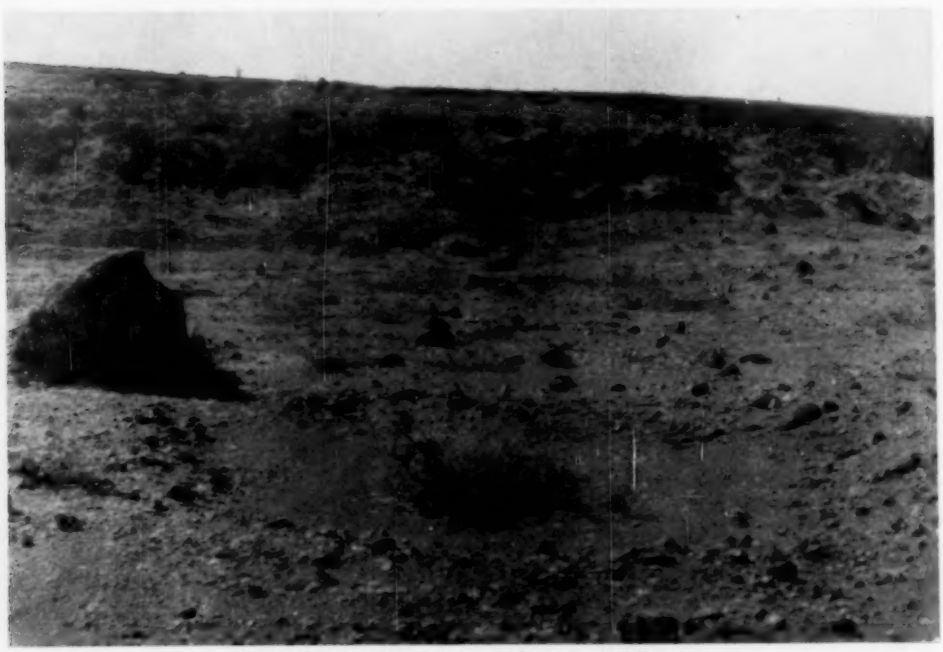

FIG. 7. Same as Figure 6, as seen from another direction.

FIG. 8. Several rings can be seen, that in the foreground having vegetation in it and broken stone at the left.

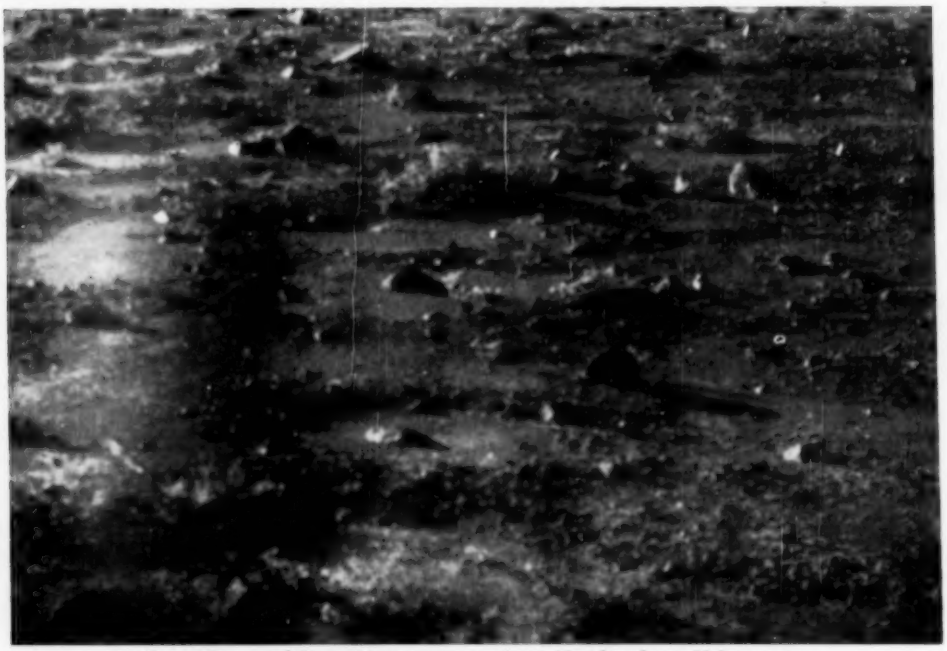

FIG. 9. Pattern of rings with stones on northern side of road near Halemaumau.

Notes on the Biology of the Wahoo in the Line Islands

EDWIN S. IVERSEN[1] and HOWARD O. YOSHIDA[2]

INCIDENTAL CATCHES of wahoo, *Acanthocybium solandri* (Cuvier and Valenciennes), have been made by the Pacific Oceanic Fishery Investigations, a branch of the U. S. Fish and Wildlife Service, during experimental tuna fishing conducted from 1950 to 1956. The exploratory fishing, which extended from 180° to 130°W. longitude and from 10°N. to 13°S. latitude, has been carried out both close to the islands and in the open sea. The bulk of our wahoo data came from the Line Islands, which from south to north are: Starbuck, Malden, Jarvis, Christmas, Fanning, Washington, and Palmyra islands, and Kingman Reef. They extend in a general northwesterly direction from 5°S. latitude and 155°W. longitude to 7°N. latitude and 163°W. longitude. Although there is no organized fishery in the islands, the copra plantation workers (Gilbertese and Ellice islanders) use beach seines to capture a variety of lagoon and reef fishes and hand lines to catch an occasional tuna or wahoo.

Most of the published reports dealing with the wahoo are brief and are concerned primarily with its occurrence and distribution. The presence of wahoo was first noted in the Line Islands by Fowler (1938: 277). Rosa (1950: 75–77) lists a number of references which are of interest principally to taxonomists. In general the biology of the species is poorly known and has not been previously considered in the central Pacific.

The wahoo, a member of the order Scombriformes, is a slender, streamlined fish with a sharp pointed head (Fig. 1). The mouth is large and is armed with razor-sharp teeth. Wahoo may weigh over 130 pounds and reach a length of nearly 7 feet. The body is steel-blue above and pale blue below. A series of bluish-black vertical bars, which fade soon after death, are present on the sides of the body. These fish are said to be very rapid swimmers and to make spectacular leaps out of the water.

The species is cosmopolitan in tropical and subtropical areas, and ranges at least as far north as Hawaii, where it is called "ono." Jenkins (1904: 441) examined wahoo in the Honolulu Market and reported that, "This is the first record of the species in Honolulu." In Hawaii today the species is of some slight importance as a sport fish. It is also sold commercially on the fresh fish market in Honolulu, but is of secondary importance. In 1953 the catch of 50,813 pounds during the year was sold for $11,166.94.

METHODS

The majority of fish available for this study were taken on standard surface trolling gear which is described by Bates (1950). This method of trolling employs about six lines attached to two long poles extending outboard, one from either side of the vessel. Trolling was mainly carried out from approximately 200 yards to 3 miles from the fringing reefs of the various islands. Some catches were also made on longline (flagline) gear, described by Niska (1954). Longline gear, which fishes well below the surface, was generally

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FIG. 1. Wahoo captured by surface trolling in the Line Islands.

used in the open ocean, but some longline stations were occupied as close as 5 to 10 miles from land.

Length measurements were made in millimeters, using calipers. The fixed arm was placed on the tip of the upper jaw with the mouth closed, and the sliding arm of the caliper was placed at the fork of the caudal fin, being careful to depress the fleshy flap (Marr and Schaefer 1949: 242). Weights were taken in pounds, using a steelyard rigged to a davit on the deck of the vessel. Some difficulty was encountered in accurately weighing the fish when the vessel was under way, but most weights were taken when the vessel was in smooth waters or at anchor.

In preparing length-frequency distributions the lengths were first combined in 4-cm. groups and then smoothed by a moving average of three. Modal groups in these distributions are defined as the size classes with the highest frequencies in the smoothed distributions. Where several adjacent size classes are similar in height after smoothing, the center of these size classes is designated as the mode.

Stomach contents of the fish were recorded in the field as soon as possible after the fish were captured. The few parasites returned to the laboratory for examinations were preserved in 10 per cent formalin.

Measurements of ova for spawning and fecundity analysis were made with a dissecting microscope, employing a micrometer eyepiece measuring in units of 0.023 mm. The eggs were not perfectly symmetrical, so to avoid selection the "diameter" measured was the distance between two lines of the micrometer tangent to the eggs, the micrometer being held in one position during a series of measurements, following the method of Clark (1934: 7).

AVAILABILITY

Wahoo do not appear to form large compact schools. This simplifies the problem of

estimating their availability. Kishinouye (1923: 412) states that wahoo do not "make a school." Taylor (1951: 278), in discussing wahoo off North Carolina, reports that they do not form schools but that males and females group in pairs at spawning time. From our trolling catches close to shore it seems that this species tends to form small, loose, feeding aggregations, since we found that occasionally several wahoo would hit the lures simultaneously. Chapman (1946: 166) believes that they may form schools, for some of the wahoo he caught near Palmyra Island had frayed caudal fins, which he attributed to crowding in schools.

Some general knowledge of the vertical and horizontal distribution of wahoo is important when estimating the availability of this species. These aspects of the distribution can be roughly inferred from a comparison of longline catches and troll catches. The longline catches are small both close to land and in the open ocean. For example, Murphy and Shomura (1953*a*, 1953*b*, 1955) and Shomura and Murphy (1955) record only 59 wahoo captured on 14 POFI experimental longline fishing cruises involving numerous stations, some close to land. This figure suggests that wahoo are never abundant at the depths fished by this gear (200–600 ft.). Trolling operations were much more productive, but only close to land. Only 12 wahoo were caught during 5,500 hours of surface trolling in the open sea, more than 60 miles from land (Murphy and Ikehara 1955: 14). In contrast, within a few miles of land in both the Hawaiian Islands and Line Islands surface catches have averaged about 1 wahoo per hour (Table 1). From this information we infer that the wahoo prefer shallow depths and are more abundant close to land.

Even near islands wahoo are not very abundant in the central Pacific. This is suggested by the low catch rates from surface trolling around the Hawaiian and Line islands (Table 1). The troll catches obtained near the Line Islands during all seasons of the year indicate that the species does not occur there in sufficient numbers to support a profitable commercial fishery. This is also true in Hawaii (Welsh 1949*b*: 29). Neither does the wahoo appear to be very abundant in the Atlantic, at least off North Carolina, where Taylor (1951: 278) states that the population is small.

It is interesting to note from the Line Islands data (Table 1) that wahoo and yellowfin tuna, *Neothunnus macropterus* (Temminck and Schlegel), have a similar pattern of seasonal variation in availability. This similarity could indicate that environmental or other factors

TABLE 1
RESULTS OF SURFACE TROLLING FOR WAHOO AND YELLOWFIN TUNA IN WATERS OF THE HAWAIIAN AND LINE ISLANDS

TIME	HOURS TROLLED	AVERAGE NUMBER OF LINES	WAHOO		YELLOWFIN	
			Number	Catch per hour	Number	Catch per hour
Hawaii						
Year around, 1947–48 (Welsh 1949b)	307	7.0	20	0.07	23	0.08
Line Islands						
April-June 1950 (Bates 1950)	285.5	6.1	178	0.62	882	3.09
March-April 1955	142.5	5.0	274	1.92	438	3.07
May-June 1955	116.0	6.0	135	1.16	100	0.86
July-August 1955	105.0	6.0	83	0.79	24	0.25
September-October 1955	182.0	6.0	245	1.35	171	0.94
November-December 1955	108.0	6.0	144	1.33	64	0.59
January-February 1956	133.5	6.0	267	2.00	148	1.10

influence both species similarly and are of greater importance than inter-specific competition for food, though both appear to feed on similar animals.

REPRODUCTION

In samples from the Line Islands, at all times of the year the percentage of males tends to be higher in the northern islands than in the southern islands (Fig. 2). This consistent trend or gradient suggests a migration of wahoo to maintain itself, unless there is varying differential mortality between sexes among areas, which seems unlikely. Such a gradient might be related to spawning movements but we are unable to describe them.

The wahoo in the Line Islands appear to spawn over an extended period of time, as is common with fish found in tropical waters.

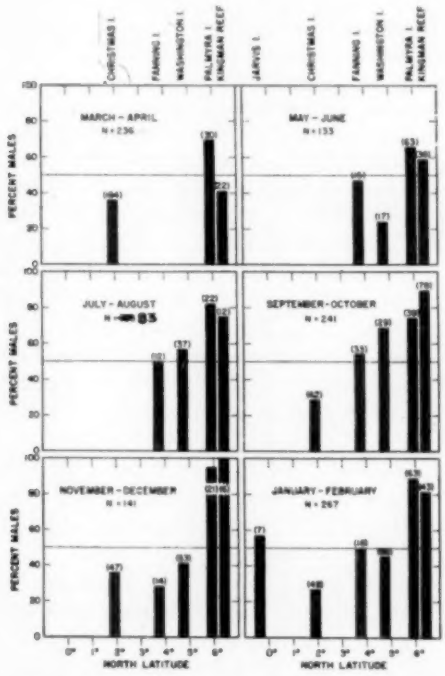

FIG. 2. Percentage of male wahoo by trolling areas, March 1955 to February 1956. (The number in each sample is shown in parentheses).

Cursory field examination of 80 females in March and of 143 in November and December, using categories devised by Marr (1948: 201),—i.e., immature, ripening, ripe, spawning, and spawned out—revealed all stages of maturity during both periods.

In order to estimate the number of eggs per spawning the size frequency distribution of ova in an apparently ripe ovary was determined for a fish of 131 cm. fork length (Fig. 3). Only eggs larger than 8 micrometer divisions, or 0.184 mm., were measured. An abundance of undeveloped or primitive eggs was present in the ovary, but most of these were not measured. The group 0.184–0.46

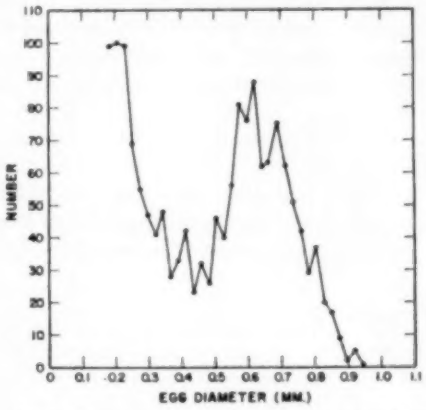

FIG. 3. Frequency distribution of egg diameters from a single female, 131 cm. fork length, captured May 1955 at Fanning Island.

mm. contained the larger of these "stockpile" eggs; the group from about 0.46 mm. to 0.94 mm., with a prominent mode at 0.62 mm. appeared to be maturing eggs. This latter group of eggs may be likened to the "type B" or developing eggs described by Tester and Takata (1953: 42) from the aholehole, *Kuhlia sandvicensis*. This one specimen showed no clear evidence of more than one mode among the developing eggs. The maturing group of eggs (> 0.46 mm.) in the ovaries of this female wahoo was estimated to number about 6.1 million. This estimate was obtained by weighing the formalin-preserved

(wet) ovaries, weighing a wedge-shaped section from one of the ovaries, and counting the number of eggs in the most mature group in this sample. The total number of mature eggs in both ovaries was then calculated by simple proportion.

This estimate of 6.1 million eggs per spawning is comparable in order of magnitude to the amount of spawn released by some other related species. Yuen (1955: 18) computed the number of eggs extruded in one spawning of a bigeye tuna, *Parathunnus sibi* (Temminck and Schlegel), in the Pacific to be 2.9 to 6.3 million; June (1953: 63) estimated the number of eggs per spawning of a yellowfin sampled in Hawaii to be 2 to 8 million. Both authors found that the number of eggs spawned increased, in general, with increase in size of fish. This probably holds true for the wahoo.

FOOD HABITS

Of the 235 stomachs examined, 115 (48.5 per cent) were empty. This relatively large number of empty stomachs may be due to regurgitation on capture. The wahoo struggles violently on the trolling line and may regurgitate food while being landed and killed. As some of the stomach contents were probably incomplete, an elaborate analysis of the food based on percentage by volume was not undertaken. Rather the analysis was confined to frequency of occurrence of the various food items.

Fish remains have a high frequency of occurrence among the food items (Table 2), and perhaps beyond their true significance since fish bones are slow to digest and hence persist longer in the stomachs than readily digested items. In both time periods (March, and November–December) mackerel scad, squid, and skipjack appear to be of importance in the food, with mackerel scad being the major item.

A much greater variety of food than is indicated by Table 2 is probably consumed by the wahoo. Very small items could have been overlooked. On infrequent occasions specimens were on deck for several hours prior to the examination of the stomachs, and the

TABLE 2
STOMACH CONTENTS OF 235 TROLL-CAUGHT WAHOO CAPTURED DURING MARCH, AND NOVEMBER-DECEMBER, 1955

FOOD ITEMS	FREQUENCY OF OCCURRENCE		PER CENT FREQUENCY OF OCCURRENCE	
	March	November-December	March	November-December
Items identifiable				
Squid (*Loligo* sp.)	6	3	18.2	13.0
Skipjack (*Katsuwonus pelamis*)	4	6	12.1	26.1
Pomfret (Bramidae)	1	1	3.0	4.4
Puffer (Tetraodontidae)	2	2	6.1	8.7
Mackerel scad (*Decapterus* [*psinnulatus*])	19	9	57.5	39.1
Flying fish (*Cypselurus* sp.)	1	..	3.0	...
Lantern fish (Myctophidae)	..	1	...	4.4
Sunfish (*Ranzania truncata*)	..	1	...	4.4
Total	33	23	99.9	100.1
Entire sample				
Empty stomachs	34	81	39.1	54.7
Fish remains not identifiable	20	44	22.9	29.7
Food remains identifiable	33	23	37.9	15.5
Total	87	148	99.9	99.9

identity of the more readily digestible forms could be lost during this time. Aside from these difficulties, it seems likely that the data in Table 2 provide a reasonably good picture of the food throughout the year. We do not believe there is much seasonal change in the fauna of the tropical Pacific.

The results of other studies suggest the diet of wahoo is similar throughout its range. Welsh (1949*a*: 22) made a preliminary examination of the food of wahoo in the Hawaiian Islands, using a rating system which considered total bulk of food, total number of food items, and the total number of times food was found in individual stomachs. Of the 17 stomachs he examined, 10 were empty. Those containing food held fish and squid. The food habits of the wahoo near Japan would seem to be nearly the same as in the Line Islands, for Kishinouye (1923: 412) states that they "feed on calamaries [squid] and pelagic fish."

LENGTH FREQUENCY ANALYSIS

An examination of the sizes of wahoo in our catches will contribute to our understanding of the biology of this species. In the Line Islands we sampled only a segment of the known size range of the species for small fish were not taken and much larger sizes have been recorded from other areas. Hosaka (1944: 69) reports a 124¾-pound wahoo taken on sport fishing gear off the island of Oahu, and LaMonte (1952: 9) reports a world record for wahoo as 133½ pounds (6 ft., 11 in.) caught in the Bahamas in 1943.

The size distribution of longline-caught wahoo is similar in most respects to that of fish taken on trolling gear. The longline catches, most of which are from the open sea, were made over several years at all months of the year and show a prominent mode at 128 cm. and a lesser mode at 146 cm. (Fig. 4). These fish range from 54 to 198 cm., with the majority between 106 and 162 cm. The measurements of troll-caught wahoo, taken mostly within 3 miles of land, during 1950, 1951, 1955, and 1956 show a similar size range, from 98 to 174 cm., and a similar distribution of sizes. It would appear then that both fishing methods sampled the same segments of a common population.

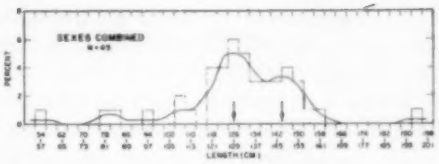

FIG. 4. Size frequency distribution of longline-caught wahoo, October 1950 to March 1955. (Smoothed by a moving average of three.)

Samples of wahoo from some islands show differences in length distribution between sexes. An example of this in distributions of wahoo taken at Christmas Island during March and April 1955 (Fig. 5) shows a slight displacement of modes. In the male distribution there is a small mode at approximately 114 cm. and a dominant mode at approximately 134 cm.; in the female distribution there is a dominant mode at about 128 cm.

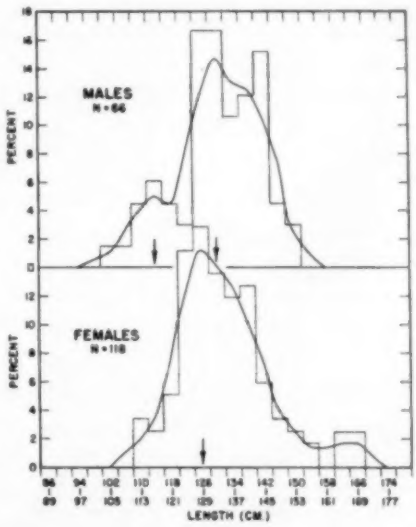

FIG. 5. Size frequency distribution of troll-caught wahoo from Christmas Island during March-April 1955. (Smoothed by a moving average of three.)

and a suggestion of a mode at approximately 164 cm. This suggests a differential growth rate between the sexes.

Wahoo show size variation associated with changes in latitude, as has been described for other scombrid fish. For example, Nakamura (1952: 101) found that the average weight of yellowfin tuna increased with latitude both to the north and south of the equator between the west coast of Sumatra and the Nicobar Islands. With respect to wahoo, the relative abundance of the larger fish appears to decrease from Christmas Island in the south to Palmyra Island and Kingman Reef in the north. This is accompanied by an increase in the numbers of smaller fish from south to north, these trends appearing in both the male and female length distributions (Fig. 6). The indications are that the wahoo are not distributed over the area in random fashion with respect to either size (Fig. 6) or sex (Fig. 2). Unless each area has a separate population with a different growth rate and sex ratio, there must be differential movement of individuals or groups in order to maintain the observed size and sex gradients. This movement, however, need not necessarily be confined to the study area.

This nonrandom distribution of the wahoo makes it almost impossible to study growth by the method of progression of dominant modes in size frequencies because of the great difficulty in obtaining representative samples. Therefore such studies were not attempted.

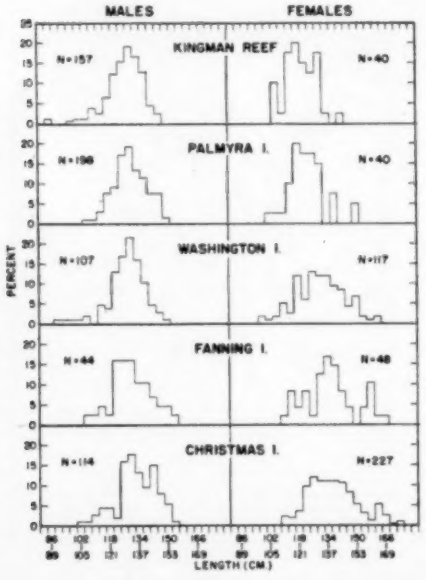

FIG. 6. Length frequency distributions of wahoo by areas, March 1955 through February 1956.

LENGTH-WEIGHT RELATIONSHIP

As no significant difference in the length-weight relationship was noted between sexes, the data were combined to calculate the following regression equation which describes this relationship in the wahoo: Log weight = $-9.4199 + 3.50583$ log length, where weight is in pounds and length in millimeters. The mean weights for given lengths may be determined from the smooth curve shown in Figure 7. This large exponent, 3.50583, reflects the elongate, slender shape of the wahoo. As one would expect for a fish of this shape, a small increase in weight yields a relatively large increase in length. On the other hand

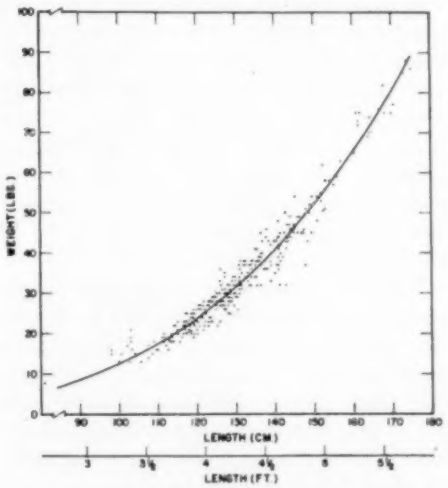

FIG. 7. Length-weight relationship for wahoo from the Line Islands, February 1951 to June 1955. Regression curve fitted by the equation: Log weight = $-9.4199 + 3.50583$ log length.

stout-bodied fish, such as some of the tuna, have a considerably smaller exponent. Examples are: yellowfin from Costa Rica, which have an exponent of 2.940 (Schaefer 1948: 119); and bigeye tuna, *Parathunnus sibi* (Temminck and Schlegel), sampled in Hawaii, which have an exponent of 2.9304 (Iversen 1955: 2).

PARASITES

Although no diligent search was made for parasites, the list given in Table 3 indicates that the wahoo is rather heavily parasitized. In the course of the examination of food items, trematodes about one inch in length when partially contracted were regularly noted at the posterior end of the stomach. Nigrelli and Stunkard (1947: 188) have carefully examined the genus *Hirudinella* and, on the basis of 33 specimens taken from wahoo captured in both the Atlantic and Pacific oceans, regard all forms of this giant trematode in the wahoo as belonging to a single species, *H. ventricosa* (Pallas).

In the 220 stomachs examined during March and November–December 1955 the number of giant trematodes per stomach ranged from 0–17 (Table 4). In all except the largest fish, two trematodes per fish were most commonly encountered, suggesting that this number represents a physiological equilibrium between host and parasite. On the other hand in the largest length group (160–179.9 cm.), four trematodes per stomach were commonly found.

SUMMARY

1. The availability of wahoo caught by trolling and longline fishing indicated the existence in the Line Islands of a small population that was most abundant in shallow water within a few miles of land.
2. Males were relatively more abundant in catches from the more northerly islands than in those from the more southerly islands.
3. Examination of wahoo gonads showed all

TABLE 3
PARASITES OF WAHOO FROM THE LINE ISLANDS, 1955

PARASITE	SITE OF INFECTION	NUMBERS PRESENT PER WAHOO	RATE OF INFESTATION	
			Per cent	Number of wahoo examined
Trematoda				
Neothoracocotyle acanthocybii (Meserve)[1]	Between gill filaments	Numerous	(high)	...
Didymocystis acanthocybii Yamaguti[1]	Head inside gill covers	Numerous cysts—2 worms/cyst	51.0	104
Hirudinella ventricosa (Pallas)	Caudal end of the stomach	0–17	98.2	220
Nematoda	Mass of worms embedded in belly wall	Many	(slight)	...
Copepoda				
Brachiella sp.	Within joint of pectoral fins	2 in each joint	98.3	118
Gloiopotes sp.	Outside surface of body and caudal fins	Many—variable	54.2	96
Pennella sp.	Embedded in belly wall with hind portion protruding	1 or 2	9.8	92

[1]Trematodes kindly identified by Dr. H. W. Manter, University of Nebraska, Lincoln.

TABLE 4
NUMBER OF GIANT TREMATODES IN STOMACHS OF WAHOO, BY HOST SIZE

NUMBER OF WORMS PRESENT	FREQUENCY OF OCCURRENCE BY HOST SIZE (CM.)							
	100–119.9		120–139.9		140–159.9		160–179.9	
	No.	%	No.	%	No.	%	No.	%
0	..	...	3	2.4	1	1.4	..	...
1	..	...	7	5.7	7	9.7	1	7.7
2	10	90.9	90	72.6	41	56.9	3	23.1
3	..	...	19	15.3	12	16.7	1	7.7
4	1	9.1	3	2.4	8	11.1	6	46.2
5	..	...	1	0.8	1	1.4	1	7.7
6	..	...	1	0.8	..	...	1	7.7
8	..	...	..	...	1	1.4	..	...
17	..	...	..	...	1	1.4	..	...
Total	11	100.0	124	100.0	72	100.0	13	100.1

stages of maturity present. The number of mature eggs in a single female was estimated at over six million.

4. The wahoo taken close to the islands showed little variety in their diet as judged by stomach contents. Of the identifiable food material the main items were mackerel scad, skipjack, and squid.
5. An examination of size frequency distributions from the Line Islands area revealed that the females attain a larger size than the males, and there is some suggestion that the two sexes grow at different rates. No attempt to estimate growth by modal progression is made since there are indications that the samples were not representative of a homogeneous population unit.
6. A length-weight relationship for wahoo from the Line Islands is given by the equation:

   Log weight (pounds) = −9.4199 + 3.50583 log length (millimeters).
7. The wahoo was found to be parasitized by trematodes, nematodes, and copepods.

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Further Evidences of Anomuran Non-pedunculate Spermatophores[1]

DONALD C. MATTHEWS[2]

MACRURAN NON-PEDUNCULATE SPERMATOPHORES were differentiated from anomuran pedunculate spermatophores by Calman (1909), but subsequent studies embracing both macrura of the Palinuridae, Scyllaridae, and Nephropsidae (Matthews, 1951, 1954*b*, 1954*c*) and the anomura of the Paguridae (Mouchet, 1931; Matthews, 1953, 1956), placed this differentiation in doubt. However, not until it was discovered that a macruran, *Parribacus antarcticus*, elaborated pedunculate spermatophores (Matthews, 1954*a*) and an anomuran, *Hippa pacifica*, elaborated non-pedunculate spermatophores (Matthews, 1956) was the dichotomy between these two tribes proven to be untenable.

This paper, which compares the development of *Aniculus maximus* spermatophores with that of certain other Paguridae, records still other instances in which anomuran non-pedunculate spermatophores are produced.

MATERIALS AND TECHNIQUES

Mature specimens of *Aniculus strigatus* Herbst (Edmondson, 1946: 264; Forest, 1952: 19, *Trizopagurus strigatus* (Herbst)), collected at Hanauma Bay, Oahu, T. H., during the year 1954, and of *A. maximus* (*vide* Edmondson, *opus cit.* p. 79), obtained from the Honolulu Aquarium during the year 1953, were used in this study.

The right testis and vas deferens of each specimen of *A. maximus* were fixed either in Bouin's or Zenker's fluid, dehydrated and cleared in dioxane, embedded in Tissuemat (54–56°C.), and serially sectioned at 10 microns. The mounted sections were stained either with Harris's alumhaematoxylin (counterstained with eosin) or with Mallory's Triple Stain.

The left vasa deferentia of both species were immersed for 10–30 minutes in an aqueous solution of toluidine blue (1–10,000), teased open in sea water, and their vitally stained spermatophores studied.

OBSERVATIONS

In cross sections throughout the testis of *A. maximus* immature sacculi containing primary spermatocytes, and more mature sacculi containing secondary spermatocytes and spermatids, are observed. These sacculi, by the renewed activity of their germinal epithelial cells, produce new primary spermatocytes which, as they fill the sacculi, force the metamorphosing spermatids into the minute collecting tubule. Thus by combined, rhythmical activities of numerous sacculi a continuous sperm mass slowly enters the proximal portion of the vas deferens where, molded in compliance with the circular lumen, it forms a rodlike sperm column.

Serial cross sections through this region of the vas deferens disclose that the shape of the lumen gradually changes from circular to elliptical, synchronously effecting corresponding changes in the shape of the sperm column.

[1] Contribution No. 93, Hawaii Marine Laboratory. Manuscript received August 14, 1956.

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As the sperm column becomes elliptical, a secretion from the epithelial cells bounding the more pointed extremities of the elliptical lumen envelops the sperm column and forms the sperm column sheath.

Serial sections through somewhat more distal regions of the vas deferens disclose that the lumen gradually becomes pear-shaped. In longitudinal sections through this region (Fig. 1) the sheathed, sperm column appears as a series of partially closed arches (*c*), joined one to another by portions of the compressed, empty, sperm column sheath (*d*).

Longitudinal sections through slightly more distal regions of the vas deferens (Fig. 2) disclose that a secretion from the epithelial cells (*f*) bordering the narrow portion of the lumen forms the foot (*e*) and fills with precursory stalk material (*d*) the spaces between the closing arches.

Thus far, the histological and physiological phenomena of spermatophoric development in *A. maximus* parallel those of *Dardanus punctulatus* (Matthews, 1956) and *Dardanus asper* (Matthews, 1953: 260–262, figs. 7, 8, 9, 10, 11) in which truly pedunculate spermatophores are ultimately elaborated.

In *D. asper*, as in *A. maximus*, the living vasa deferentia exhibit spasmodic contractions which serve both to move the sperm mass and to mold it in compliance with the gradually changing internal die, i.e., first cylindrical, then elliptical, then pear-shaped. In *D. asper* also, a secretion from epithelial cells isolated at opposite ends of the elliptical lumen forms the sperm column sheath. And this sheathed sperm column, by muscular contractions of the wall of the vas deferens, forms partially closed arches, joined one to another by portions of the compressed, empty, sperm column sheath. In *D. asper*, too, a secretion from the epithelial cells bordering the narrow portion of the pear-shaped lumen forms the foot and fills with precursory stalk material the spaces between the closing arches.

From this stage of development on, the processes in the elaboration of pedunculate and non-pedunculate spermotophores diverge. This divergence results, for the most part, from subsequent activities of the epithelial cells bounding the lumen.

In *D. asper* (*op. cit.*, p. 263, figs. 12, 13), the epithelial cells at the narrow region of the pear-shaped lumen form a groove into which the precursor of the stalks is secreted. As the groove deepens, the stalk material lengthens both by the continued secretion of the epithelial cells and by the muscular contractions in the walls of the vas deferens. It is noteworthy that the lengthening of the stalks carries the ampullae of sperm "above" the foot and that the connecting sperm column sheaths between adjacent ampullae become extremely thin and finally obscure. Even in the short spermatophores of *Birgus latro* and *Coenobita rugosus* (Matthews, 1956) the stalks are lengthened sufficiently to carry the ampullae of sperm "above" the foot.

In *A. maximus* (Fig. 3) the epithelial cells (*f*) fail to form a deep groove into which the precursor of the stalks is secreted. Instead, this region of the lumen (*d*) widens and the secretion from the epithelial cells spreads out forming the broad foot (*e*). Noteworthy also is the sectioned portion of an arch (*c*), which here measures 112 microns high and 71 mi-

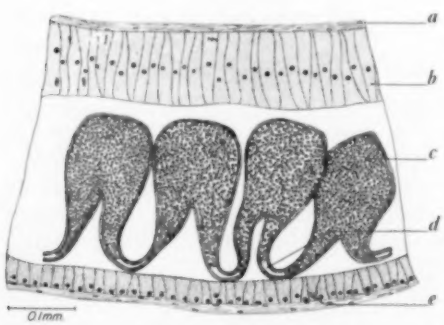

FIG. 1. Longitudinal section of the proximal vas deferens of *Aniculus maximus* showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, partially closed arches of sheathed, sperm column; *d*, compressed, empty sperm column sheath connecting partially closed arches; *e*, short, epithelial cells bounding narrow portion of lumen.

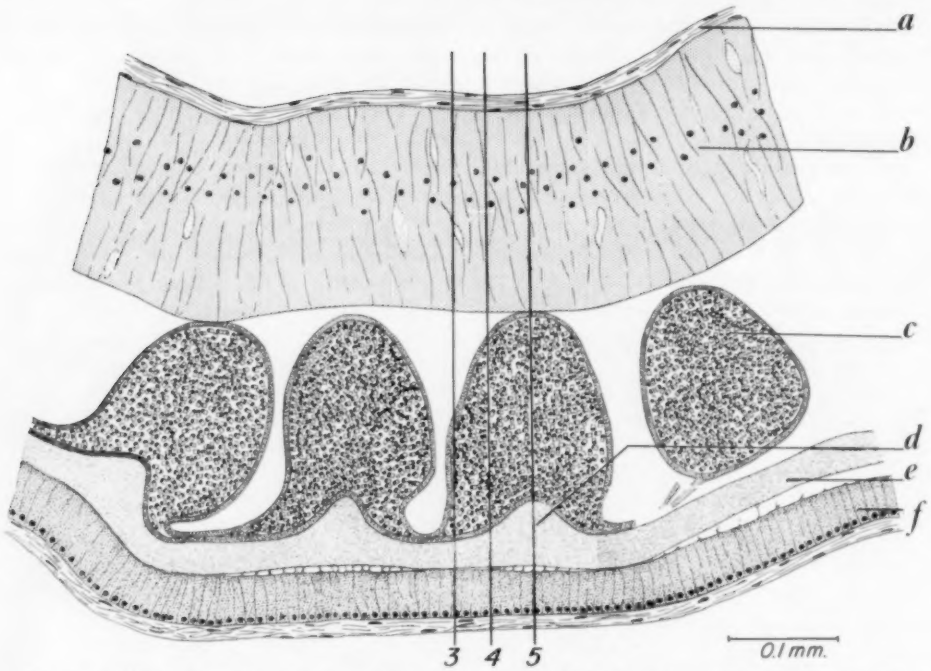

FIG. 2. Longitudinal section of the proximal vas deferens of *Aniculus maximus* (slightly distal to Fig. 1) showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, sectioned portion of arch; *d*, precursory stalk material; *e*, foot; *f*, short epithelial cells of narrow portion of lumen secreting the foot material. (The numbers 3, 4, 5 show regions through which Figs. 3, 4, 5 are taken.)

crons wide and appears like a distinct ampulla resting on the broad foot (*e*).

In subsequent sections through this region of the vas deferens (Fig. 4) although the foot forming epithelial cells (*f*) do not shorten, the epithelial cells (*b*) "above" the sectioned portion of the arch (*c*) attain a length of approximately 182 microns. Again it is noteworthy that the sectioned portion of the arch (*c*) appears like a distinct ampulla 171 microns high and 118 microns wide. Whereas, in Figure 3 the "ampulla" appeared to rest firmly on the broad, basal foot, in Figure 4 it is "elevated" approximately 12 microns by the sectioned portion of the stalk precursor (*d*).

In still other cross sections through this region of the vas deferens (Fig. 5) neither the foot forming epithelial cells (*f*) nor the epithelial cells (*b*) above the sectioned portion of the arch (*c*) change appreciably in length. And again it is noteworthy that the sectioned portion of the arch (*c*) appears like a distinct ampulla, 171 microns high and 118 microns wide. The "ampulla" is elevated approximately 35 microns above the foot (*e*) by the sectioned portion of the stalk precursor (*d*).

The broad groove so characteristic of this portion of the lumen is no longer encountered in cross sections through the enlarged, apical portion of the vas deferens (Fig. 6). Gradually, the epithelium becomes folded and two typhlosole-like regions (*b*) appear at opposite sides of the lumen. From the epithelial cells bordering the crypts of these typhlosole-like folds, a new mucus-like secretion forms the matrix (*c*) which encompasses the completed spermatophores.

Because of its tortuous nature, both cross sections (*e*) and longitudinal sections (*d*) of

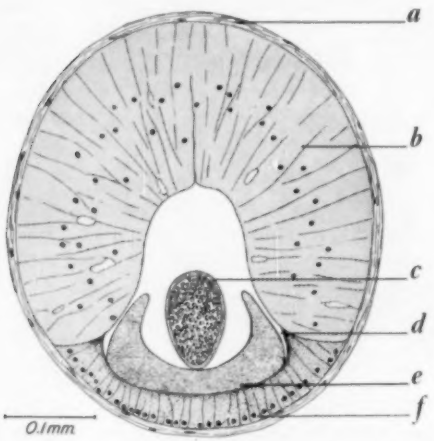

FIG. 3. Cross section of the proximal vas deferens of *Aniculus maximus* (through region 3 of Fig. 2) showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, sectioned portion of arch; *d*, portion of wide lumen; *e*, foot; *f*, foot-forming epithelial cells.

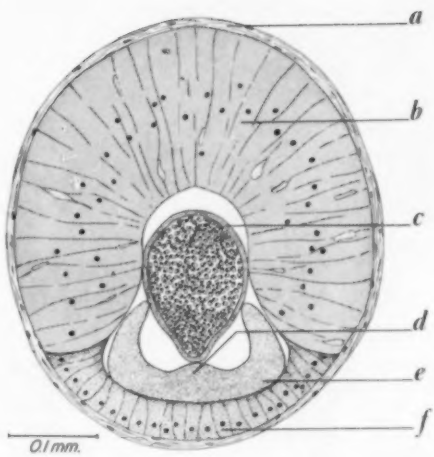

FIG. 4. Cross section of the proximal vas deferens of *Aniculus maximus* (through region 4 of Fig. 2) showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, sectioned portion of arch; *d*, stalk precursor; *e*, foot; *f*, foot-forming epithelial cells.

the spermatophore are here observed. Conspicuous also in these sections are the longitudinal muscles (*a*) which probably serve to eject the completed spermatophores (Fig. 7).

When the enlarged apical portions of the vasa deferentia of *A. strigatus* and *A. maximus* are placed in toluidine blue and their encompassing mucus-like matrices are dissolved (in 0.1N KOH), continuous, non-pedunculate spermatophores (Fig. 7) are revealed. Here is final evidence that the arches (*a*) never completely close forming distinct ampulla and that the arches are in reality never raised above the broad basal foot (*b*).

DISCUSSION

Mouchet (1931) assigns nine regions of activity to the vas deferens of the typical pedunculate spermatophore producing hermit crab, *Diogenes pugilator* Roux (Matthews, 1953: 264). The spermatophoric differences observed in *A. strigatus* and *A. maximus* are attributed to vasa deferentia which lack one or more of these regions. We are especially concerned in this discussion with region 4, in which each ampulla acquires a short thick stalk, and with region 6, in which the stalks are stretched.

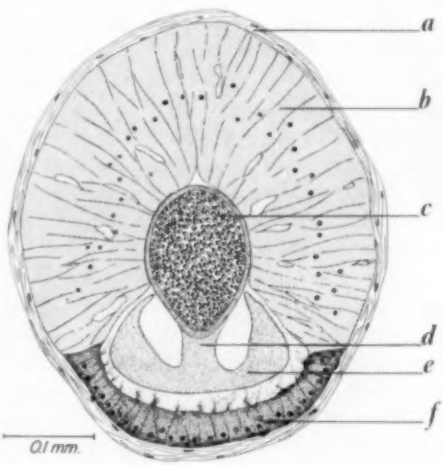

FIG. 5. Cross section of the proximal vas deferens of *Aniculus maximus* (through region 5 of Fig. 2) showing: *a*, muscle layer; *b*, elongate epithelial cells; *c*, sectioned portion of arch; *d*, stalk precursor; *e*, foot; *f*, foot-forming epithelial cells.

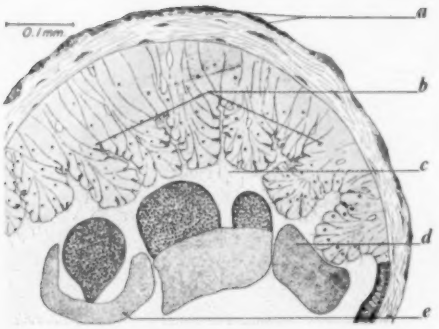

FIG. 6. Portion of cross section through enlarged distal vas deferens of *Aniculus maximus* showing: *a*, circular and longitudinal muscles; *b*, typhlosole-like region of epithelial cells; *c*, mucus-like matrix; *d*, longitudinal section through portion of spermatophore; *e*, cross section through portion of spermatophore.

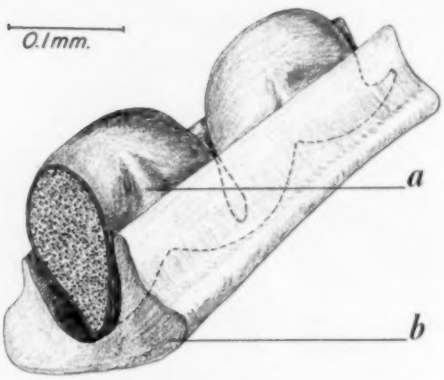

FIG. 7. A composite drawing of vitally stained extruded spermatophores of *Aniculus strigatus* or *Aniculus maximus* (with matrix dissolved away) showing: *a*, unclosed arch not elevated above foot; *b*, foot.

In my observation of the stained cross sections of *A. maximus* I am unable to determine with certainty whether region 4 is present or not. True, both cross and longitudinal sections reveal a "stalk precursor" which fills the spaces of the closing arches but this material, with the stains employed, could not, either in texture or staining affinity, be differentiated from that of foot. It is not the intent of this paper to base pedunculation on whether or not the "stalk precursor" is a separate and distinct secretion from that which forms the foot, but rather to point out that, despite its origin, region 6, where this secretion should be stretched, is lacking. The lack of this region has a pronounced effect on the ultimate elaboration of the spermatophores, for without it the arches are never truly "elevated above" the floor of the foot. That they may appear so in isolated cross sections of the vas deferens (Figs. 3, 4, 5) points to the need to consider both cross and longitudinal sections before statements concerning raised isolated ampullae can be made. Taken alone, Figure 3 and especially Figures 4 and 5 convey the erroneous impression that, indeed, the closed arches form isolated ampullae and that these are elevated on short stalks above the broad basal foot. In reality this is not true, as is seen when Figures 3, 4, and 5 are studied in relation to their position in the longitudinal section of the vas deferens (Fig. 2, regions 3, 4, 5).

This condition in *A. strigatus* and *A. maximus* is not new. Mouchet (1931) points out that the hermit crabs *Eupagurus bernhardus*, *E. prideauxi*, *E. cuanensis*, *Anapagurus hyndmanni*, and *Clibanarius misanthropus* likewise lack regions 4 and 6 in which the stalk is secreted and stretched. Although I have not investigated the spermatophoric development of these hermit crabs, it appears rather unlikely that distinct ampullae of sperm are elevated above the foot. If not, the spermatophores of these hermit crabs should be included with those of *A. strigatus* and *A. maximus* as further evidence of non-pedunculate spermatophore formation in the Paguridae.

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Spiders from Some Pacific Islands, II[1]

B. J. MARPLES[2]

I AM INDEBTED to Dr. N. L. H. Krauss for the collection of spiders which is described here. The specimens, with the exception of a paratype of the male of *Leucauge ilatele* retained in my own collection, will be deposited in the Bernice P. Bishop Museum in Honolulu. The collection contains examples of some 40 species from Tahiti, Raiatea, Moorea, and Borabora in the Society Group; from Aitutaki in the Cook Islands; from Upolu and Savaii in Western Samoa; from Tongatabu and from several localities in Viti Levu in the Fiji Islands Experience with other collections from the islands has shown that species which are common on one occasion may be rare or absent on another, and so it has seemed advisable to list the numbers of individuals collected from each locality, whether the species has been recorded previously or not. There are many new records, inasmuch as little or no collecting has been done in some islands. In some families identification can only be tentative until a thorough revision has been carried out. It has been felt in some cases that it is zoogeographically less confusing to erect new species or genera for island spiders, than to force them into, for example, continental Australian genera which are inadequately characterised. Attention is drawn to such doubtful cases in the text, and this should be borne in mind in any consideration of faunae. A great deal of work is still needed before we have an adequate picture of the spider fauna of the Pacific islands, and still more of its relation to those of adjacent land masses. Berland (1934*a* and *b*) has described the spiders of Tahiti and has also listed those known from Polynesia, together with their distribution. The spiders of Samoa were described by Marples (1955).

In the descriptions the measurements were made with an eyepiece micrometer and are given in millimetres. The leg indices are derived by dividing the length of each leg by the length of the carapace, and the tibial indices, which give a measure of the stoutness of the legs, by dividing the combined lengths of the tibia and patella by the proximal breadth of the patella. The eye measurements are given in direct scale readings, so indicate the proportions only.

LIST OF SPECIES RECORDED

FILISTATIDAE

Filistata bakeri. Tahiti.

ULOBORIDAE

Uloborus bistriatus. Samoa.
Uloborus geniculatus. Fiji.
Uloborus gibbosus. Samoa, Fiji.

[1] Part I was published in Pacific Science 9(1): 69–76, 1955. Manuscript of Part II was received May 3, 1956.

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SICARIIDAE

Scytodes marmorata. Fiji.
Scytodes striatipes. Society Islands, Samoa.

CLUBIONIDAE

Chiracanthium spp. Society Islands, Samoa, Tonga.

SPARASSIDAE

Heteropoda venatoria. Aitutaki.

THOMISIDAE

Diaea praetexta. Samoa, Tonga, Fiji.

SALTICIDAE

Bavia aericeps. Society Islands, Aitutaki, Samoa, Fiji.
Savaiia punctata. Samoa.
Menemerus bivittatus. Society Islands, Samoa, Fiji.
Mollicia microphthalma. Society Islands, Aitutaki.
Plexippus paycull. Fiji.
Sandalodes calvus. Society Islands.
Ascyltus pterygodes. Samoa, Fiji.
Athamas whitmei. Samoa.
Cytaea piscula. Samoa.
Thorellia ensifera. Society Islands, Aitutaki, Samoa.
Vitia albipalpis. Fiji.

THERIDIIDAE

Conopistha gracilis. Samoa.
Theridion albostriatum. Aitutaki, Fiji.
Theridion kraussi. Fiji.

TETRAGNATHIDAE

Tetragnatha keyserlingi. Society Islands, Samoa.
Tetragnatha laqueata. Society Islands.
Tetragnatha macilenta. Samoa, Fiji.
Tetragnatha nitens. Society Islands.
Tetragnatha panopea. Society Islands, Samoa.
Leucauge granulata. Samoa.
Leucauge ilatele. Samoa.
Leucauge prodiga. Samoa, Fiji.
Leucauge tuberculata. Society Islands, Samoa.

EPEIRIDAE

Anepsia rhomboides. Samoa.
Argiope pentagona. Fiji.
Cyclosa littoralis. Samoa.
Epeira flavopunctata. Fiji.
Epeira pogisa. Samoa.
Epeira theisi. Society Islands, Samoa, Fiji.

FILISTATIDAE

Filistata bakeri Berland

1 ♀ Papeete, Tahiti. First record for the Society Islands. Previously recorded from the New Hebrides, Samoa, the Austral, Phoenix, and Christmas islands.

ULOBORIDAE

Uloborus bistriatus L. Koch

1 ♀ Sili, Savaii, Western Samoa. First record for Savaii, but it is common in Upolu and occurs also in Fiji.

Uloborus geniculatus Olivier

A widespread species throughout the tropics. Specimens from Viti Levu, Fiji: 2 ♀ Naliumba, 1 ♀ Korolevu, 1 ♀ Suva.

Uloborus gibbosus L. Koch

1 ♀ Savaii, the first record. 2 ♀ Upolu, 5 ♀ Lami, Viti Levu.

SICARIIDAE

Scytodes marmorata L. Koch

1 ♂, 2 ♀ Singatoka and Korolevu, Viti Levu. The first record for Fiji. Previously recorded from New Caledonia, Samoa, Tahiti, and Hawaii.

Scytodes striatipes L. Koch

1 ♀ Raiatea. The first record for Raiatea, but a widespread species already recorded from the Society Islands. 1 ♀ Upolu.

CLUBIONIDAE

Fourteen specimens are included in the collection, but only 3 seem certainly to be mature. All appear to belong to the genus *Chiracanthium*, of which 7 species have been described from the area, but in no case could the present specimens be certainly identified. The figures given by Koch for epigyna are difficult to compare with actual specimens. The teeth on the margins of the cheliceral groove also do not correspond, and Berland (1938) states that, in *C. longimanum* at least, they are variable. In the present series the numbers of teeth vary from 3 to 5 on the promargin, and from 2 to 4 on the retromargin. A tentative identification is 1 ♀ *C. furax* L. Koch from Nukualofa, Tongatabu, though the dark mark on the carapace is not present. This would be a new record, the species being described from Samoa. Another is 1 ♀ *C. gilvum* L. Koch from Raiatea. This species has been recorded from Australia, New Caledonia, New Hebrides, and Samoa. The 14 specimens were collected as follows: 1 from Raiatea, 1 from Borabora, 4 from Upolu, 3 from Tonga and 1 from Fiji.

SPARASSIDAE

Heteropoda venatoria (Linn.)

1 ♀ and 1 imm. Aitutaki, first record. This species has a worldwide distribution in tropical countries and is common in the Pacific area.

THOMISIDAE

Diaea praetexta L. Koch

All the Thomisids appear to be the same and to belong to this species. All however have little or no marking on the abdomen, but variation in this respect has been noted by Berland (1929). The records for Savaii 1 ♀, Nukualofa 2 ♀, and Viti Levu 11 ♀, are new.

SALTICIDAE

Bavia aericeps Simon

1 ♀ imm. Aitutaki, 1 ♀ imm. Sili, Savaii, 1 ♂ imm. Lomeri, Viti Levu. These are new records, the species having been recorded in Malaya and in various islands across the Pacific as far as the Marquesas. 1 imm. Tahiti, 1 ♀ and 1 imm. Raiatea.

Savaiia gen. nov.

Unidentate. Carapace low and flat, nearly twice as long as broad. Row of bristles with dark bases on each side of carapace and on the prolateral side of femur I. Spines on all legs. Resembles *Flacilla* Simon except that this is without spines.

Savaiia punctata sp. nov.

1 ♀ Savaii.

FEMALE. Length 5.49 mm. Carapace chestnut brown, darker in the ocular area and black around the eyes. Light patch at the thoracic groove. Chelicerae, maxillae and lip chestnut brown, legs and sternum pale brown. Abdomen pale brown with dark dorsal pattern. This consists of a pair of elongated patches followed by two pairs of square patches partially joined middorsally, followed by a single dorsal patch immediately anterior to the anal tubercle and spinnerets which are dark.

Carapace: Length 2.01 mm., breadth 1.30 mm., breadth of anterior row of eyes 0.94 mm. Low, flat dorsally and slightly widest at the level of legs III. Posterior slope gradual, no clypeus. On each side in the pale area below the eyes, and extending the whole length of the ocular area, is a row of 10 bristles arising from dark sockets.

Eyes: Ocular quadrangle slightly wider behind. Anterior row, seen from in front, slightly recurved. Ratios of the diameters of the eyes and of their distances apart: AM, 171; AL, 91; PM, 43; PL, 105; AM-AM, 46; AM-AL, 23; AL-PM, 138; PM-PM, 553; PM-PL, 108; L-L, 288; PL-PL, 542; overall breadth of anterior row, 583; overall breadth of third row, 642.

Chelicerae: Small, with pale hairs on the prolateral surface. Groove oblique. A single pointed tooth centrally placed on the retromargin of the groove, two teeth close together at the ventral end of the promargin.

Maxillae: Converging but not meeting, rounded anteriorly.

Lip: Longer than broad, narrower anteriorly.

Sternum: Length 0.87 mm., breadth 0.46 mm., oval.

Palp: The claw appears spoon shaped and is turned prolaterally at right angles to the axis of the tarsus. The palp is covered with pale hairs and there are three dark bristles on the patella and one on the tibia.

Legs:	IV	I	III	II	Palp
	1.67	1.32	1.23	1.16	0.54

	FEMUR	PATELLA AND TIBIA	METATARSUS	TARSUS	TOTAL
Palp	0.47	9.36	...	0.26	1.09
I	0.90	1.07	0.43	0.26	2.66
II	0.79	0.89	0.38	0.28	2.34
III	0.78	0.92	0.46	0.32	2.48
IV	1.05	1.25	0.66	0.41	3.37

Tibial Index I 3.5
Tibial Index IV 6.2

Leg I much the stoutest especially the femur which is somewhat flattened and expanded dorsoventrally. On the prolateral surface at the distal end is a row of 6 hairs arising from dark sockets, appearing at first sight like a black line. Claws with 2 pectinations. Spines: Metatarsi; I, 2 proventral, 1 retroventral; II, 1 proventral, 1 retroventral; III and IV, 5 spines arranged around the distal end. Tibiae: I, 1 prolateral; II, none; III, 1 proventral, 1 retrolateral; IV, 1 proventral, 1 retroventral and 1 retrolateral. Femora with 3 dorsal and 1 prodorsal stout bristles. Trichobothria in a single row on the tarsi and metatarsi and a double row on the tibiae.

Abdomen: Length 3.03 mm., breadth 1.76 mm. Elongated oval, epigynum as in Figure 1.

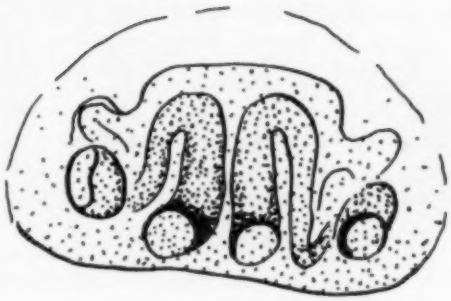

FIG. 1. *Savaiia punctata.* Epigynum.

Menemerus bivittatus Dufour

1♂ Korolevu, Viti Levu. A widespread species not apparently recorded previously from Fiji. 1♂, 2♀ Tahiti; 1♂, 1♀ Upolu.

Mollicia microphthalma (L. Koch)

1♂, 1♀ and 3 imm. Papeete, Tahiti. 1♂ from the mountains near Uturoa, Raiatea. 1♂ Akaiami, Aitutaki. The specimen from Raiatea is larger than the others. The species is known from New Caledonia, and the Loyalty Islands in the west, and from Rarotonga, Tahiti, the Marquesas, and Hawaii.

Plexippus payculli Audouin

1♀ RakiRaki, Viti Levu, first record from Fiji. A cosmopolitan species known from many parts of the Pacific.

Sandalodes calvus Simon

1♀ Huahine. First record from Huahine though it is known from others of the Society Islands. 1♂, 1♀ Tahiti; 12♀ Raiatea.

Ascyltus pterygodes (L. Koch)

1♂, 3♀ and 5 imm. Sili, Palauli and Tapueleele, Savaii. 2♂, 1♀ and 2 imm. Kolo-i-Suva, Korolevu, Lami and Nandarivatu, Viti Levu. Known previously from Tahiti and Upolu. 1 immature male from Lautoka, Viti Levu, may belong to another species, two of which

in this genus have been described from Fiji. Some of the females from Savaii are much smaller than usual but seem to belong to this species. 12 ♀ Upolu.

Athamas whitmei Cambridge

1♂ Upolu.

Cytaea piscula L. Koch

4♂ and 1♀ Sili and Palauli, Savaii. New record. Previously known from Upolu, Tutuila and Australia. 5♂ Upolu.

Thorellia ensifera (Thorell)

6♂ and 2 imm., 5♀ Papeete, Tahiti. 1♀ Raiatea. 1♂ Akaiami, Aitutaki. 1♂ Upolu. It is a common and widespread species, but not previously recorded from Tahiti or Aitutaki.

Vitia gen. nov.

Fissidentate. Carapace moderately high and rounded. Palp of male long and slender with simple bulb and small apophysis.

Vitia albipalpis sp. nov.

1♂ RakiRaki, Viti Levu.

MALE. Length 5.05 mm. Carapace dark reddish brown shading to black around the eyes. Behind the eyes is a crescent-shaped area of lighter chestnut brown, its points anterior to the ALE, the broad central part extending from the level of the PLE more than half way towards the posterior margin of the carapace. Chelicerae and maxillae chestnut brown, legs darker brown especially the anterior pair. Palps brown except for the distal end of the femur, the dorsal and prolateral surfaces of the patella and the prolateral surface of the tibia. These are thickly covered with white hairs, longest on the tibia. Abdomen brown with darker mottlings and a white recurved crescent anterodorsally. Ventral surface pale.

Carapace: Length 2.67 mm., breadth 1.98 mm., breadth of anterior row of eyes 1.73 mm. Moderately high, slightly rounded in outline. Thoracic groove a black line, its anterior end level with the black of the PLE. Few bristles around the eyes.

Eyes: Anterior row recurved. Ocular quadrangle slightly wider in front. Ratios of the diameters of the eyes and of their distances apart: AM, 300; AL, 188; PM, 47; PL, 166; AM-AM, 22; AM-AL, 50; AL-PM, 234; PM-PM, 870; PM-PL, 146; PL-PL, 761; L-L, 420; clypeus, 92; overall breadth of anterior row, 1000; overall breadth of third row, 972.

Chelicerae: A bifid tooth on each margin of the groove, the prolateral being the larger and wide at the base, the retrolateral constricted at the base.

Maxillae: Slightly converging, wider and evenly rounded anteriorly.

Lip: Longer than broad, concave at the tip.

Sternum: Length 0.91 mm., breadth 0.74

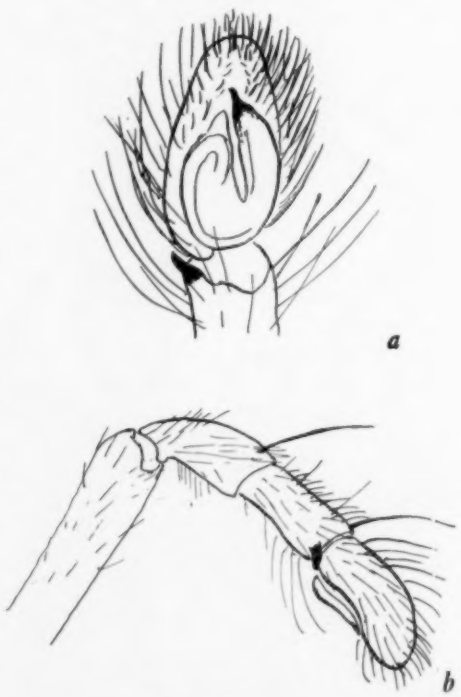

FIG. 2. *Vitia albipalpis*. *a*. Ventral view of right palp. *b*. Retrolateral view of right palp.

mm. Blunt behind, margin concave opposite coxae III and IV.

Palp: As in Figure 2. Rather long and slender with the tarsus little swollen. Short retrolateral apophysis at the distal end of the tibia. The conspicuous white hairs on the palp have been mentioned above.

Legs:	III	IV	I	II	Palp
	2.03	2.00	1.99	1.73	0.88

	FEMUR	PATELLA AND TIBIA	METATARSUS	TARSUS	TOTAL
Palp	0.80	0.96	...	0.59	2.35
I	1.61	2.27	0.93	0.50	5.31
II	1.51	1.84	0.75	0.54	4.64
III	1.77	1.87	1.17	0.60	5.41
IV	1.53	1.82	1.38	0.63	5.36

Tibial Index I 6.1
Tibial Index IV 6.0

Claws: The retro with 4–6 large pectinations, the pro with 3 or 4 minute ones in addition at the proximal end of the row. Spines: Metatarsi I and II with 2 pairs, III with a circlet of spines at each end, IV with spines in the middle as well as at the ends. Tibiae: I, 3 pairs and 1 proximal prolateral: II, 2 prolateral, 2 pairs and 1 proximal retroventral; III and IV, 1 distal pair and 1 proventral, 3 pro and 3 retrolateral, 1 proximal dorsal. Patellae: I and II, 1 prolateral; III and IV, 1 pro and 1 retrolateral. Femora: 1, transverse distal dorsal row of 3 followed by 2 dorsal. II, III and IV have 4 in the transverse row. Trichobothria: In a single row on tarsi and metatarsi and a double row on tibiae.

Abdomen: Length 2.39 mm., breadth 1.52 mm. Ovoid.

This spider resembles some from Australia placed by Koch in several poorly characterized genera. It seems best to place it in a new genus until the position is clearer, rather than to suggest on doubtful grounds a faunal affinity between Fiji and Australia.

THERIDIIDAE

Conopistha gracilis (L. Koch)

1♀ Savaii. 1♀ Upolu.

Theridion albostriatum L. Koch

1♂ Aitutaki. 1♂, 1♀ Korolevu, Viti Levu. These specimens are somewhat doubtfully placed in this species, recorded from Australia and Tonga. They appear to be the same as some collected in buildings in Upolu (Marples 1955) and also tentatively placed here.

Theridion kraussi sp. nov.

1♀ Kolo-i-Suva, Viti Levu.

FEMALE. Length 4.58 mm. Colour brown, abdomen lighter in front and on the sides. Sternum with 3 lateral and a posterior median dark marks.

Carapace: Length 1.54 mm., breadth 1.24 mm. Heart-shaped, the cephalic part projecting forward with prominent eyes, AME overhanging the clypeus, thoracic part domed. Smooth surface with some scattered bristles almost all on the cephalic part.

Eyes: 8. AME dark, the remainder light with reddish pigment. From above the anterior row strongly recurved, posterior row straight. Breadth of eye group 0.56 mm. Ratios of the diameters of the eyes and of their distances apart: AM, 193; AL, 142; PM, 164; PL, 163; AM-AM, 135; AM-AL, 46; AM-PM, 182; PM-PM, 147; PM-PL, 138; L-L, 0; clypeus, 365.

Chelicerae: Slender, joined at base, no boss. 3 teeth on the promargin of the groove.

Maxillae: Long, very much longer than the lip, converging but not meeting. Scopula on median margin and anterior median angle. Black serrula lateral to it.

Lip: Twice as broad as long.

Sternum: Length 0.88 mm., breadth 0.79 mm. Three slight indentations on each side. Posterior blunt point between coxae IV which are well separated.

Palp: Claw with 4 pectinations and pectinated bristles on the tarsus. Two pairs of trichobothria on the tibia. Tarsal organ 24 per cent of the length of the tarsus from its distal end.

Legs:	I	IV	II	III	Palp
	4.43	3.58	3.41	2.50	0.81

	FEMUR	PATELLA AND TIBIA	METATARSUS	TARSUS	TOTAL
Palp	0.37	0.41	...	0.48	1.26
I	2.08	2.14	1.87	0.78	6.87
II	1.67	1.56	1.41	0.65	5.29
III	1.21	1.08	1.01	0.57	3.87
IV	1.74	1.71	1.42	0.67	5.54

Tibial Index I 10.1
Tibial Index IV 8.4

Three claws, the dorsal ones with 3 or 4, the median one with 1 pectination. Spurious claws, except on IV, and pectinated bristles. Bristles, pectinated on both sides, along tarsus and the distal end of metatarsus IV. No spines. Tarsal organ on I, 63 per cent of the length of the tarsus from the distal end.

Abdomen: Length 3.11 mm., breadth 2.47 mm. Rounded, spinnerets ventral. Anterior spinnerets largest, and close together. Other spinnerets in a transverse line, the median small and compressed between the posterior ones. Anal tubercle small and transverse, no colulus. Epigynum as in Figure 3.

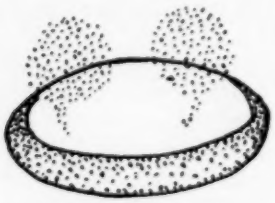

FIG. 3. *Theridion kraussi.* Epigynum.

The presence of teeth on the cheliceral groove may exclude this species from the genus *Theridion*, but it seems best to place it here tentatively.

TETRAGNATHIDAE

Several species of *Tetragnatha* have been recorded from the South Pacific area, but they seem to be subject to a considerable amount of variation in colour, in the size and position of the eyes, and in the cheliceral teeth. The following identifications are accordingly more or less uncertain.

Tetragnatha keyserlingi Simon

2♂, 3♀ from Tahiti. These differ from the descriptions in colour and in the cheliceral teeth and are only very doubtfully placed here. 1♂ Raiatea. 2♂, 1♀ Upolu.

Tetragnatha laqueata L. Koch

1♀ from Opoa, Raiatea. Previously recorded only from Samoa.

Tetragnatha macilenta L. Koch

1♂ from Lami, Viti Levu, a new record. 12♀ Upolu, 1♂, 4♀ Savaii.

Tetragnatha nitens (Audouin)

1♀ from Baie de Cook, Moorea. This is a species with a very wide distribution, from the Mediterranean to several of the Pacific islands.

Tetragnatha panopea L. Koch

1♀ from Borabora. Previously recorded from Lord Howe Island, the New Hebrides, Ellice Islands, and Samoa. 1♀ Savaii.

Leucauge granulata Walckenaer

According to Dalmas (1917) the species referred to by L. Koch as *Leucauge granulata* Walck. is not properly so called but should be *Leucauge dromedaria* (Thorell). It occurs in Australia, New Zealand, and several of the Pacific islands as far east as Tahiti. It has not been recorded from Samoa. One specimen in the present collection from Sili, in Savaii, may belong to it. It resembles New Zealand specimens in shape and colour, but it is considerably smaller.

Leucauge ilatele Marples

2♂ Apia, Upolu. Described from the female only from Upolu.

MALE. Length 3.84 mm. Pale yellowish

brown, the abdomen covered with smaller silvery marks leaving a clear dorsal stripe. Brown round the eyes and at the thoracic groove.

Carapace: Length 1.76 mm., breadth 1.40 mm., breadth of eye group 0.63 mm. Low, with longitudinal groove smooth pear-shaped outline.

Eyes: 8, all pale. From above, anterior row strongly recurved, posterior row straight. Ratios of the diameters of the eyes and of their distances apart: AM, 135; AL, 145; PM, 160; PL, 166; AM-AM, 131; AM-AL, 117; AM-PM, 133; PM-PM, 107; PM-PL, 130; L-L, 0; clypeus, 205.

Chelicerae: Groove oblique, 3 promarginal and 4 retromarginal teeth, the proximal ones of each row situated on the rim of the articular membrane, which is large, of the fang. A blunt tooth retrolaterally placed near the last retromarginal tooth.

Maxillae: Wider distally and curving outwards.

Lip: Broader than long, truncated anteriorly where it is rebordered and has 2 bristles at each corner.

Sternum: Length 0.72 mm., breadth 0.87 mm. Heart-shaped. Margin convex and rebordered opposite coxae I, slightly concave opposite the other coxae. Extends between coxae IV as a slender process bifurcated at the waist.

Palp: As in Figure 4. Large bulb, cymbium with 2 apophyses at the proximal end, one blunt and directed dorsally, one sharp and curved and directed prolaterally.

Legs:

I	II	IV	III	Palp
7.85	4.67	3.87	2.25	1.27

	FEMUR	PATELLA AND TIBIA	METATARSUS	TARSUS	TOTAL
Palp	1.03	3.84	...	0.82	5.69
I	3.75	4.61	4.37	1.07	13.80
II	2.42	2.58	2.47	0.73	8.20
III	1.28	1.16	1.04	0.48	3.96
IV	2.29	2.12	1.85	0.52	6.80

Tibial Index I 18.1
Tibial Index IV 12.3

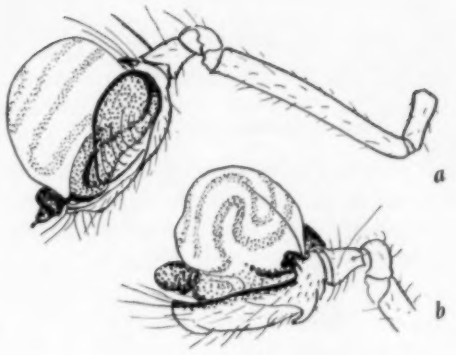

FIG. 4. *Leucauge ilatele*. *a*. Retrolateral view of left palp. *b*. Prolateral view of right palp.

Many of the spines are missing from these specimens but they seem to have been fewer than in the female. Five small trichobothria in two rows on the prolateral side of the base of femur IV.

Abdomen: Length 2.14 mm., breadth 1.22 mm. Slight dorsal hump about one third of the length from the anterior end.

Leucauge prodiga L. Koch

1 ♀ Lami, Viti Levu. Previously recorded from Samoa. 2 ♀ Upolu, 2 ♀ Savaii.

Leucauge tuberculata Keyserling

3 ♀ from the mountains near Uturoa, Raiatea, 1 ♀ from Baie de Cook, Moorea. First records from the Society Islands, previously recorded from Fiji, Samoa, and Tonga. 2 ♂, 5 ♀ Savaii. 8 ♀ Upolu.

EPEIRIDAE

Anepsia rhomboides L. Koch

5 ♀ Sili, Savaii. The first record, but the species is common in Upolu. 11 ♀ Upolu.

Argiope pentagona L. Koch

1 ♀ Lami, Viti Levu. Previously recorded from Ovalau, also in the Fiji Islands.

Cyclosa littoralis L. Koch

14 ♀ Savaii. First record. Common in Upolu and recorded also from Fiji. 1 ♀ Upolu.

Epeira flavopunctata L. Koch

1 ♂ from Nandarivatu, Viti Levu. This species was described from a single male from Fiji, and the present specimen agrees with it except in the pattern on the abdomen.

Epeira pogisa sp. nov.

1 ♀ Apia, Upolu.

FEMALE. Length 5.28 mm. Carapace, sternum, mouth parts, coxae and femora pale yellowish brown. Distal parts of legs darker and obscurely banded. Dorsal side of abdomen dark reddish brown mottled with light yellowish. Very little pattern, but an ill-defined median band of the dark colour, bordered with light. It is narrow in front but broadens about one third from the posterior end, at which point there is a procurved transverse band. Ventral side of abdomen and the spinnerets pale yellowish brown mottled with white behind the epigynum.

Carapace: Length 2.58 mm., breadth 2.05 mm., breadth of eye group 1.32 mm.

Eyes: From above, both rows recurved. Ratios of the diameters of the eyes and of their distances apart: AM, 177; AL, 165; PM, 157; PL, 144; AM-AM, 213; AM-AL, 400; AM-PM, 175; PM-PM, 146; PM-PL, 510; L-L, 0; clypeus, 95.

Chelicerae: 4 teeth on the promargin of the groove, the third from the fang being considerably the largest. 3 teeth on the retromargin.

Maxillae: Truncated anteriorly, ventral surface distinctly convex.

Lip: Broader than long.

Sternum: Length 1.08 mm., breadth 1.01 mm.

Palp: Claw with 9 pectinations.

Legs:	I	II	IV	III	Palp
	3.59	3.37	3.24	1.70	1.01

	FEMUR	PATELLA AND TIBIA	METATARSUS	TARSUS	TOTAL
Palp	0.78	0.89	...	0.96	2.63
I	2.77	3.53	2.22	0.96	9.43
II	2.50	3.29	2.04	0.89	8.72
III	1.39	1.43	0.99	0.58	4.39
IV	2.38	2.60	2.72	0.68	8.38

Tibial Index I 9.2
Tibial Index IV 7.2

Claws: I, pectinations, pro 8, retro 10, median 2. Spines: I, metatarsus, 5 proventral, 3 retroventral, 1 retrolateral, 1 dorsal. Tibia, 3 proventral, 3 prolateral, 2 retroventral, 3 retrolateral, 3 dorsal. Patella, 2 prodorsal, 2 dorsal, 2 retrodorsal. Femur, 3 proventral, 1 prolateral, 2 dorsal, 1 retrodorsal. II, metatarsus, 4 proventral, 2 dorsal, 3 retroventral, 1 retrolateral. Tibia, 2 proventral, 4 prolateral, 2 dorsal, 3 retroventral, 1 retrolateral. Patella, as in I. Femur, 1 prodorsal, 1 dorsal, 1 retrodorsal. III, no spines, some stouter bristles. IV, metatarsus, 3 proventral, 4 retroventral. Tibia, 1 ventral, 2 retroventral, 2 dorsal, 3 prodorsal, 3 retrodorsal. Patella, 1 prodorsal, 1 retrodorsal. Femur, 1 prodorsal, 1 dorsal, 1 retrodorsal.

Abdomen: Length 3.23 mm., breadth 2.39 mm. Covered with short pale hairs and long dark bristles. Epigynum a dark conspicuous broad-ended projection, as in Figure 5.

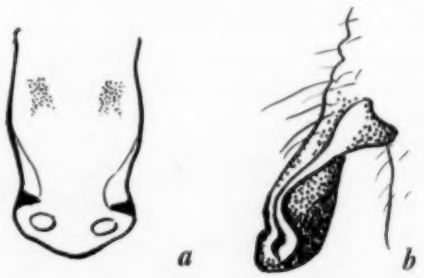

FIG. 5. *Epeira pogisa*. *a*. Ventral view of epigynum. *b*. View of epigynum from left side.

Five species of *Epeira* were recorded from Samoa by Koch. Berland recorded three of them in 1929, one represented in his collection by only a single specimen, and stated that *E. maculaticeps* appeared to be the most widespread species. As a result of four months collecting in 1945–46 and 1950–51 I obtained 93 specimens from many localities in Upolu and off-lying islets, all of which appeared to be *E. theisi*. The present specimen corresponds with none of these species, and as far as I can determine it appears to be new. The name suggested is the Samoan word for "dark," with reference to the colour.

Epeira theisi Walckenaer

This is a widespread tropical species found in many Pacific islands. In the present collection there are specimens from Tahiti, Raiatea, Borabora, Upolu, Savaii, and Viti Levu.

SUMMARY

A collection of some 40 species of spiders from the Society Islands, Aitutaki, Western Samoa, Tonga, and Fiji is described. Two new genera and four new species are proposed as follows: Salticidae, *Savaiia punctata* and *Vitia albipalpis*, Theridiidae, *Theridion kraussi*, Epeiridae, *Epeira pogisa*. The male of *Leucauge ilatele* Marples is also described. There are many new distributional records, especially from Aitutaki, which has no previous records, and from Savaii and Viti Levu, which have few.

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Studies on the Johnstonianidae (Acari, Parasitengona)

IRWIN M. NEWELL[1]

THE SUBFAMILY Johnstonianinae Thor 1935 (Trombidiidae) was established to include *Johnstoniana* George 1909 and related genera. The only comprehensive treatment of the group was published by Thor and Willmann (1947) who included eight species in the genera *Centrotrombidium* Kramer 1896, *Johnstoniana*, *Diplothrombium* Berlese 1910, *Myrmicotrombium* Womersley 1934, and *Hirstithrombium* Oudemans 1928.

The present study was undertaken with a view to placing the systematics of the Johnstonianinae on a sound morphological basis, and to determine the relationship of the group to other terrestrial Parasitengona. It soon became apparent that the mites included in the Johnstonianinae differed so significantly from other terrestrial Parasitengona that they could not logically be retained within the family Trombidiidae Murray 1877.[2] The differences are much greater than those which have been cited, for example, to establish Trombiculidae Ewing 1944 as a family separate from the Trombidiidae. The group is therefore raised to family rank with *Johnstoniana* George 1909 as the type genus.

Interest in the group was stimulated by numerous indications that this is perhaps the most primitive existing family, terrestrial or otherwise, within the Parasitengona. The indications of this are of ecological, behavioral, and morphological nature.

Ecologically the Johnstonianidae are terrestrial in larval, nymphal and adult stages, but are rarely found where there is not an ample supply of water nearby; in fact many of them could be aptly termed subaquatic. Thus, ecologically they are in a position from which they (or their antecedents) could evolve in two directions—either toward strictly terrestrial forms such as the Trombidiidae, or toward the subterrestrial aquatic mites such as the Limnocharidae, Thyasidae, etc., and thence to the more strictly aquatic Parasitengona. From an evolutionary standpoint, it might be hypothesized that the Parasitengona parasitic on insects evolved before those on terrestrial vertebrates, because insects appeared first in the fossil record. This assumes that there were appropriate predatory Acari present when the hosts appeared, but since the earliest fossil record of the Trombidiformes (*Protacarus* Hirst, Devonian) is at least contemporaneous with that of the earliest known Insecta, this is not an impossible assumption. The next major group of hosts to become available to the Parasitengona were the Amphibia, and the seemingly close structural similarities between *Hannemania* species (which largely parasitize Amphibia) and the Johnstonianidae, which parasitize insects living in moist habitats, is suggestive that these are phylogenetically very close. This close relationship could have arisen in more than one way—either by the direct descent of the Amphibia-parasites from the early Johnstonianidae, or by simultaneous radiation of the Amphibia-parasites and the Johnstonianidae from a common ancestral mite or group of mites which appeared at the same time as or somewhat later than the Amphibia. The extent to which the Parasitengona have become adapted to the Insecta

[1] University of California, Riverside, California. Manuscript received April 17, 1956.

[2] While many derivatives of the name *Trombidium* Fabricius 1775 were published prior to 1876 (see Oudemans 1937: 1349–1361), the first unequivocal use of the name Trombidiidae appears to be that of Murray (1876) in his Economic Entomology. Accordingly the writer ascribes the family name to Murray 1876 rather than to Leach 1815, who employed the name Trombidides, and not Trombidiidae.

would suggest that the only thing that might possibly have prevented the parallel emergence of the latter two groups would have been the unavailability of a suitable prototype mite at the time the insects were first becoming established. The groups with larvae parasitic on higher vertebrates appear to be more modified than the Johnstonianidae and *Hannemania* (although not more so than the Trombidiidae or Erythraeidae which parasitize insects).

So far as their habits are concerned, the larvae of the Johnstonianidae are all parasitic, but the relationship between larva and host is very loose. Among the Parasitengona there are two extremes in the relationship of larva to host—in some species the larva is little more than a predator, preying upon a number of host individuals during its development, and detaching readily when disturbed. At the other extreme we find larvae which, once firmly attached, remain with the host until they complete their larval development almost regardless of what stimuli may intervene. A simple test of the degree of host fixity is to drop the host with the attached larvae into a vial of 60 per cent alcohol. Forms in which host fixity is highly developed will usually remain attached, unless they had not become firmly attached to the host or unless they were in the process of detaching themselves at the time of capture. Forms in the other group detach readily regardless of how long they have been on the host, and for this reason they are called "self-detaching larvae." All Johnstonianidae which the author has studied in the living state have larvae of the self-detaching type.

Morphologically they appear to be more generalized than other Parasitengona. For example, there are two pairs of sensilla on the scutum in most species, such as are found in the Erythraeidae and most Smarididae, but with obvious trends toward modification or loss of the anterior pair as in the Trombidiidae and Trombiculidae. The simplicity of the body setae and those of most leg segments would appear to be a primitive characteristic contrasting with the more ornate setae found in other families. The possession of a large complement of supracoxal, vestigial, and rostral setae would also seem to be primary in the Parasitengona, secondary reductions in these being most notable in the Trombidiidae and Trombiculidae. It should be pointed out, however, that notable differences in these occur within the limits of the family. The possession of well-developed paragenital sclerites also seems to be a primitive characteristic. These are probably found in all genera of terrestrial Parasitengona, although in many they lack setae and are nearly invisible. The generalized structure of the palpal tarsus of the larva, and the presence of a single subterminal spiniform seta on the adult palpal tibia, appear in sharp contrast to the greatly reduced tarsus of the larvae of the Trombidiidae, and to the elaborately developed ctenidium of the adults of many genera outside of the Johnstonianidae. These are some of the principal morphological indications of the primitive nature of the group. The detailed morphology of these and other structures will be discussed below, along with others not mentioned here.

ACKNOWLEDGMENTS

The present study was initiated under a contract between the Office of Naval Research (Nonr-782(00), and the University of Hawaii while the writer was on the staff of the Hawaii Agricultural Experiment Station. It was continued under a research grant (NSF-G1833) from the National Science Foundation to the University of California. Much of the work, including the field study program for 1953, has been supported by research grants from the University of California. Without the assistance of these foundations and institutions, the present work would have been most improbable.

Mari Riess of the University of California at Riverside made about 200 of the camera lucida drawings; while the remainder were

done by Helen Au Randall, formerly of the University of Hawaii. In these figures, the scales provided are marked in 10 μ units, except for the few marked in 100 μ units. The latter are drawn with a double base line, and also have the total length indicated on the scale.

This is not intended to be an exhaustive review of the species assignable to the family. While such might be desirable, as a matter of fact existing descriptions are so inadequate that a thorough review of the group is impossible until all species have been redescribed. Only where it was felt that a specific contribution to knowledge could be made on the basis of the descriptive material available has mention been made of previously named forms. For example, the genus *Polydiscia* Methlagl is shown to belong in the family, at least provisionally, and a brief mention of *Crossothrombium* Womersley, omitted from recent catalogues, is included to bring it to the attention of other workers who might also overlook it.

MORPHOLOGY

In describing these and other mites, the writer has found it useful to develop a system of notation of the position of specialized setae or other features on the segments of the legs and palpi. It is frequently necessary to indicate the precise position of these, but at present there is no brief, convenient method for doing so. The system will be illustrated by an example. The position of the seta or other structure is stated with reference to the proximal and distal ends of the segment. For instance, the statement "tarsus II with a spikelike famulus at 0.61*pd*" means that famulus$_2$ is located at a point 0.61 of the length of the tarsus from the proximal end, and on the posterodorsal aspect of the segment. The terms dorsal, ventral, anterior, and posterior, are utilized to express position with relationship to the longitudinal axis of the legs. The terms lateral and medial are not employed, since the meaning of these terms is reversed on legs I and II as compared with III and IV. The reader should visualize the legs as protruding from the sides of the body at right angles to the main axis of the body. For the sake of morphological uniformity, the same orientation should be visualized in the case of the pedipalps despite the seeming incongruity of the pedipalps of a mite projecting at right angles to the median axis of the body. The terms preaxial and postaxial are in some respects preferable to anterior and posterior, in referring to the segments of appendages, but the writer prefers to use anterior and posterior because the symbols *a* and *p* are immediately understandable, avoiding the necessity of using either two-letter symbols, or others which are less readily comprehensible. In the following descriptive accounts, the symbol *a* following a decimal in the designation of the position of a particular seta or structure means anterior, *p* = posterior, *d* = dorsal, *v* = ventral, *ad* = anterodorsal, *pd* = posterodorsal, *av* = anteroventral, and *pv* = posteroventral. This method of notation greatly simplifies the problem of precise location of setae, and also makes it possible to analyze variation in the positions of specific setae. By the use of special graphical methods it is possible to directly determine the positions of the specialized setae with ease and rapidity, without the necessity of making measurements and converting these to decimals.

In naming the specialized setae of the appendages, the writer has adopted the system first propounded by Grandjean, beginning in 1935. The only modification was the addition of a system of notations for the several types of solenidia found on the legs. The Grandjean system of setal nomenclature is based primarily upon the form and physical properties of the setae, rather than upon their position. The solenidia are thin-walled setae showing spiral or annular internal structure in most types, although some solenidia do not show any internal structure. Typically the

solenidia taper very little throughout their length, and the distal end is usually rounded. Ornamentation is almost invariably wanting, and the cuticle is optically inert in polarized light. The eupathidia are similar to the solenidia in certain respects, but there is usually no internal structure (an exception is illustrated in Fig. 238). External ornamentation is more likely to be found than in the solenidia, in the form of short barbs (Figs. 215, 216, 217) and the cuticle is nearly always partially anisotropic. Birefringence is most noticeable in the basal portion. The walls of the eupathidia are typically of uniform thickness throughout —slightly thicker than the solenidia and thinner, relatively, than the normal setae. Notable transformations in structure of the eupathidia are found in certain cases, as in those on the tarsus of the palp. For example, in the genera *Centrotrombidium*, *Johnstoniana*, and *Diplothrombium*, typical eupathidia are found on the palpal tarsus of the adult (Figs. 59, 83, 159), while in the larva the apparent ontogenic forerunners of these are heavy, pectinate, sometimes elaborately formed setae, with little or no trace of a central canal (Figs. 29, 92, 132).

The other types of setae provide no particular difficulties in interpretation and will be discussed below with reference to their characteristics and distribution in the Johnstonianidae.

Scutum

A number of interesting and illuminating trends can be seen in the structure and chaetotaxy of the scutum of the Johnstonianidae. The first is a reduction or a modification of the anterior pair of sensilla, leading to their eventual disappearance, or their transformation into setae which are not at all sensillar in form. While it might be argued that the trend is the reverse, that is, toward the development of the anterior pair of sensilla, this does not appear to be the most likely alternative. In *Johnstoniana* there is a well defined anterior pair of sensilla in both larva and adult (Figs. 70, 90). Also, in the larva of *Lassenia scutellata* there is a well defined anterior pair of sensilla, borne on a small sclerite separated from the remainder of the scutum by a narrow band of striated membranous cuticle (Fig. 249). In the adults of *Lassenia spinifera*, these anterior setae (Fig. 232) are scarcely recognizable as sensilla because the alveoli are not to any sensible degree different from those of the other setae of the scutum. But there is little doubt that the two short simple setae on the spine of the adult scutum actually are the anterior sensilla. In the larva of *Lassenia lasseni* the anterior sensilla are present, although the alveoli of these are not as well developed as the alveoli of the posterior pair of sensilla (Fig. 214). Nevertheless these are unquestionably the anterior sensilla. They are short and distinctly barbed, in marked contrast to the posterior pair which are long, slender, and smooth. In fact the anterior sensilla more closely resemble the other setae on the scutum than they do the posterior sensilla. In the adult of the species (Fig. 183) there is only one well defined pair of sensilla. At the same time there is usually a pair of stiff, rodlike setae near the anterior margin of the scutum, somewhat set apart from the rest of the setae. If one were to examine only the nymphs and adults of *Lassenia lasseni* there would be considerable justification in stating that this species was characterized by the possession of a single pair of sensilla. Yet there is no doubt that the anterior two rodlike setae on the adult scutum are derived from the anterior sensilla of the larva, and are therefore homologous with them, regardless of their remarkable transformation in form. Thus within the one genus *Lassenia* we see a partial obscuring of the anterior pair of sensilla between the larval and adult stages.

Genera in other families of Parasitengona should be re-examined to determine those in which the anteromedian setae of the scutum are homologous with the anterior sensilla for it is evident from the Johnstonianidae that this can be expected. Such is almost certainly

the case in *Hannemania*, *Leeuwenhoekia*, and related genera in which the resemblance to some of the Johnstonianidae is augmented by the possession of an anteromedian spine on the scutum. If these are homologous with the anterior sensilla, then it is further likely that the single anteromedian seta found in many of the Trombiculidae is also homologous with the anterior sensilla, which have somehow or other become fused. Only in such genera as *Gateria*, *Walchia*, *Gahrliepia* and *Schöngastiella* do the anterior sensilla (or their paired or unpaired homologues) appear to be totally lacking. The recognition of the essential unity of these setae at the anterior end of the scutum will help greatly in the analysis of evolutionary trends within the Parasitengona. The modifications of the anterior sensilla in the Johnstonianidae provide the key.

In *Diplothrombium monoense*, we find that it is the adult rather than the larva in which the anterior sensilla are best developed (Figs. 110, 129). And, finally, in *Centrotrombidium* the anterior sensilla are completely absent in both larva and the adult. Some authors have referred to the anterior pair of setae on the scutum of *Centrotrombidium* as a second pair of sensilla, but a comparison of Figures 4 and 110 will show that this is not the case; rather the anterior pair of setae in *Centrotrombidium* are undoubtedly the homologues of the setae which, in *Diplothrombium*, lie between the two pairs of sensilla; the anterior sensilla are totally lacking.

Another interesting variant is found in the degree of duplication of the setae of the scutum other than the sensilla. In *Centrotrombidium* and *Diplothrombium*, the setae anterior to the posterior sensilla undergo little or no reproduction in the transformation from the larva to adult, except perhaps in *D. micidium*. The larva of this species is as yet unknown (unless it should prove to be the larva described here as *D. cascadense*) so it is not possible to state positively whether or not there has been a duplication of these setae in this particular species. If we assume that the larva does have a single pair of setae between the anterior and posterior pairs of sensilla, which is probably the case, then there is a moderate degree of duplication of these setae (Fig. 160).

In *Diplothrombium monoense* there is a moderate degree of duplication of these setae as a rule, for there is usually a second pair of setae near the margin of the plate between the anterior and posterior pairs of sensilla (Fig. 110). Considering the situation in *D. micidium*, it is probable that these can be regarded as a duplication of the setae in question. The situation in *Johnstoniana* and *Lassenia* is somewhat more complex, for there are usually five to nine or more setae which we could regard as the ontogenic descendants of the intersensillar setae of the larva.

In addition to the chaetotactic features described above, there is a further variant in the structure of the scutum. In both *Centrotrombidium* and *Diplothrombium*, there is a noticeable tendency toward the formation of a posterior stalk with a feebly sclerotized lateral expansion in the adult (Figs. 4, 63, 110, 160). No corresponding development is found in the scutum of either *Lassenia* or *Johnstoniana*. Associated with the tendency toward the differentiation of the posterior lobe of the scutum, is the degree of development of the lateral portion of the scutum outside the crista. The broadest scutum is found in *Johnstoniana*, a somewhat narrower plate in *Lassenia*, and the narrowest scuta are found in *Diplothrombium* and *Centrotrombidium*.

There is also a noticeable difference in the crista metopica, for this structure is well developed in the larva of *Johnstoniana* and *Diplothrombium*, very feebly developed in the posterior part of the scutum of *Centrotrombidium*, and essentially absent from the larval scutum of *Lassenia*. A unique variant in the form of the posterior sensilla is found in *Centrotrombidium*, in which the distal portion of the shaft is greatly expanded and pyriform to spherical in form.

Corneae

The eyes of the Johnstonianidae show little variation. There are typically two well-developed corneae borne on a small ocular plate on either side of the scutum. While these frequently protrude prominently, they are not so well developed that they could be described as stalked, except in *Johnstoniana*, in which the ocular plates are definitely cylindrical and raised well above the surface of the propodosoma (Fig. 86). About the only variant in the form of the corneae is found in *Centrotrombidium*. In this genus only the anterior cornea is developed in the adults of the species known to the writer; the posterior cornea is represented by a prominent but nonhyaline protuberance (Fig. 53). In none of the forms seen by the writer are there any setae on the ocular plates, either in the larva or in the adult. According to Womersley, the eyes are absent in *Crossothrombium*.

Dorsal Setae of Hysterosoma

There are two outstanding features of the dorsal chaetotaxy of the Johnstonianidae. The first of these is the insertion of the dorsal setae of the larvae in individual sclerites which show no sign of fusion in any of the known forms. The second feature is the rather poor development of setal ornamentation, especially in the adults. As in the larva the setae of the adults are also borne on individual sclerites, although these are relatively smaller than in the larva. In all species studied, the dorsal setae in the adult are completely smooth, and are frequently stiff, short, and rodlike (Fig. 183). In the larva the setae are always arranged in four or five well defined rows (Fig. 131). The dorsal setigerous sclerites in the larva are always flat or weakly arched, but in the adult they are characteristically elevated, forming either low hemispheres or short cylindrical protuberances above the general surface of the cuticle (Fig. 64).

Dorsal Propodosomal Setae

In none of the known larvae are there any setae outside the scutum. In the adult however, there is a tendency toward the development of setae lateral to the scutum and even lateral to the ocular plate. In *Johnstoniana latiscuta* (Fig. 86) there are no setae whatever lateral to the scutum. In *Lassenia lasseni* there is a single pair of setae, or occasionally more, between the scutum and the ocular plate, but the great majority of the propodosoma outside of the scutum is bare (Fig. 183). The situation in *Lassenia spinifera* is somewhat different, for in this species there are quite a number of setae surrounding the ocular plate although these are by no means as abundant as on the dorsum of the hysterosoma; and moreover there is an appreciable difference in form between the dorsal setae of the propodosoma and hysterosoma (Fig. 232). In *Centrotrombidium* and *Diplothrombium*, there are generally several setae between the scutum and ocular plates, although again the density of setae here is in no way comparable with that on the dorsum of the hysterosoma.

Coxal Chaetotaxy of Larva

The situation with respect to this character is not entirely clear owing to the small number of species known in each of the genera. In each of the four species of *Centrotrombidium*, *Diplothrombium*, and *Johnstoniana* which have been adequately described there are two setae on coxa I and one seta on each of coxae III and IV (2–1–1). Only two species are known in the genus *Lassenia*, the coxae of *L. lasseni* having the setal formula 2–2–3, and *L. scutellata* having the setal formula 2–1–2. Thus it is possible that in the genus *Lassenia* the number of coxal setae in the larvae is only a specific character, while in the other thrree genera it may prove to be generically constant. The supracoxal setae of the legs are discussed below along with the other specialized setae of the appendages.

Pars Medialis Coxae

This is the name applied to the small extension of the medial angle of coxa I of most

adult terrestrial Parasitengona (Figs. 54, 82, 154, 192). In many cases, especially in the adult, it is difficult to tell whether this is a part of coxa I or II, or whether it is a distinct sclerotized area independent of the coxae. However, in those species in which coxae I and II are rather distinctly separated, and in which a distinct pars medialis coxae is developed, it is clear that this is an extension of the coxa of leg I. In those cases in which the relationship is not so clear, it is probably safe to assume that the pars medialis coxae is morphologically a part of coxa I rather than II.

The number of setae present on the pars medialis coxae is quite variable even within the limits of a given species. At best, variations in this structure appear to be of a specific rather than a generic nature. An interesting variant is found in the genus *Lassenia*, in which *L. lasseni* has a well-defined pars medialis coxae in the adult (Fig. 192) whereas in *L. spinifera* (Fig. 234) the pars is entirely absent. In the latter species there is a general reduction in the degree of sclerotization of the coxae for many of the setae which normally would be included within coxae II actually lie in the membranous cuticle immediately behind the posterior margin of these (Fig. 234). It is interesting to note that when there is a difference in the form of the setae of coxae I and the intercoxal area such as exists in *Diplothrombium micidium* (Fig. 154) and *Lassenia lasseni* (Fig. 192) the setae of the pars medialis coxae are more similar to those of the intercoxal area than they are to those of the coxae themselves.

Coxal Ring

In the Parasitengona, the coxae have become largely incorporated into the ventrolateral body wall as a series of well-defined plates. However, if one examines the distal portion of the typical coxa of an adult it is found that this comprises a cylinder of extremely short length, and it is this peripheral portion which the author refers to as the coxal ring. The distal portion of the coxa is ringlike in the adults of most species of terrestrial Parasitengona, except for leg I, in which the coxal ring is generally, if not always, incomplete dorsally (Fig. 107b). This is the situation in the adults of all genera except *Lassenia*, in which the two known species have both coxal rings I and II incomplete dorsally in the adult (Fig. 232). In all species of all genera of the Johnstonianidae, coxal rings III and IV are complete dorsally (Fig. 107a).

Urpore

The urpore is present in the larvae of all known species of Johnstonianidae and is well developed. There are no variants of known generic significance.

Lassenia Organ

This is a term which the author has applied to a structure of unknown nature and function immediately anterior to coxa III of larvae and adults of certain of the Johnstonianidae. It is especially well developed in *Lassenia lasseni* and *Lassenia scutellata* (Figs. 199, 209, 221, 251). A search of specimens of *Johnstoniana* and *Centrotrombidium* has failed to reveal a corresponding organ in these genera. At least a rudiment of this organ is found in larvae of *Diplothrombium monoense*, and *D. cascadense*, but not as yet in the adults of these species. A systematic search of other Parasitengona might reveal other groups in which this organ is found. It is most likely a gland of unknown function for in a number of specimens, both larva and adult, a duct leads from the body surface into the incompletely hydrolyzed remains of a glandlike mass of cells. Beyond this its nature is unknown.

Genital and Paragenital Sclerites of Adult

The Johnstonianidae are somewhat unusual among the Parasitengona in that the genital and paragenital sclerites are almost equally developed. Thus the genital opening is surrounded by four sclerites of very nearly equal size, and bearing roughly equal numbers of

setae. In fact, in *Diplothrombium micidium* the setae on the paragenital sclerites actually outnumber those on the genital sclerites proper. In the other terrestrial Parasitengona, the paragenital sclerites bear markedly fewer setae than the genital sclerites, if they bear any at all. There are invariably three pairs of genital acetabula in both the male and female. The penis of the male is relatively very small. A unique variant in the genital area is found in *Lassenia* in which there is a well developed pregenital tubercle. In *Lassenia lasseni* this makes its first appearance in the protonymph and increases in size in the deutonymph and adult. In *L. lasseni* it is a simple hemispherical tubercle, while in *L. spinifera* it is an elongate peduncle. In both cases it is heavily sclerotized and pigmented in the mature adult. Not even a rudiment of this pregenital tubercle has been found in the larvae, nymphs or adults of any of the other genera.

Anal Area

In all genera but *Lassenia* and *Polydiscia* the anal anlage of the larva is a simple slit with no associated setae. In both *Lassenia lasseni* and *L. scutellata* the slit is guarded by a pair of anal sclerites bearing two pairs of simple, smooth setae. The anal sclerites of the adults of all but *Johnstoniana* are distinctively crescentic in form, bearing in most cases a single row of smooth, simple setae (Figs. 18, 105, 240). In *Lassenia spinifera* there are two rows of setae on the anal sclerites, whereas in at least one male of *Lassenia lasseni*, the two anal sclerites had only 0 and 1 setae respectively. Perhaps the most significant variant is found in *Johnstoniana latiscuta* in which there are no anal sclerites at all (Fig. 68). There is a poorly defined anal area bearing a number of setae and differing from the surrounding cuticle only in the absence of striae.

Rostral Setae

The situation with regard to these setae cannot be finally resolved until further studies are made in other families. However, if we take *Lassenia lasseni* as a starting point, we find in the larva of that species three pairs of setae on the gnathosoma, all of these on the rostrum (Fig. 229). These will be called the proto-, deuto-, and tritorostral setae, and the presence of these three pairs is a condition characteristic of the larvae of many genera of the terrestrial Parasitengona. The protorostral setae are generally located dorsally or dorsolaterally on the tip of the rostrum, not only in this species but in the terrestrial Parasitengona in general. (These are the so-called "galeal setae" of specialists in the Trombiculidae. The writer prefers the term "protorostral setae" because it is simpler to give these three topographically related setae parallel names than to coin separate ones for each.) In *L. lasseni*, the deutorostral setae are under the margin of the velum in both the larva and the adult (Figs. 188, 229), while the tritorostral setae lie directly behind them. In *Centrotrombidium distans*, *Diplothrombium* and *Johnstoniana* there are only two pairs of setae in the larva (Figs. 45, 170, and 88). The distal pair of setae obviously are the protorostrals while the basal pair are either deutorostrals or tritorostrals. In larvae of *Centrotrombidium distans* (Fig. 45) a pair of very minute structures of uncertain nature is found along the margin of the velum in approximately the position occupied by the deutorostral setae of *Lassenia lasseni*. Apparently homologous structures are found in the adult as well (Figs. 2, 17). These may represent highly modified setae, or they may simply be points of insertion of muscles associated with the velum. Homologous structures have been found also in adults of *Diplothrombium monoense*, but neither in the adults nor the larvae of *Johnstoniana latiscuta*. From their position alone these would appear to be homologous with the deutorostral setae of *Lassenia* so that the series *Lassenia*—(*Centrotrombidium*, *Diplothrombium*)—*Johnstoniana* represents a progressive diminution in the size and importance of the deutorostral setae. This conclusion should be verified with studies in related genera and

families, but at present this appears to be the situation in the Johnstonianidae. In none of the larvae of the Johnstonianidae studied so far are there any setae behind the tritorostrals corresponding to the posterorostrals of some genera.

In the adults, of course, the base of the gnathosoma is generally covered with a considerably greater number of setae. An interesting exception is found in *Lassenia spinifera* (Fig. 248), in which only one pair of setae is added behind the tritorostrals; in *L. lasseni* (Fig. 180) many more setae are found here. In adults of *Centrotrombidium* (Fig. 17) the number of setae is apparently never great, but these are small species. The largest number of setae found behind the tritorostrals is in *Diplothrombium* and *Johnstoniana* (Figs. 125, 66).

It is difficult to say whether or not the setae found behind the tritorostrals are to be considered the ontogenic descendants of the tritorostral setae, but this does not appear to be the case, for the tritorostrals often retain a fairly characteristic appearance, differing rather markedly from the setae behind them (Figs. 23, 106). We would therefore have to consider these setae as having arisen *de novo* in the postlarval instars.

Velum

This structure appears to show few variants of any significance in the family. It is a simple structure of moderate size in all species studied by the writer.

Posterolateral Arms of Gnathosoma

Only moderate trends are noticeable within the family, with *Johnstoniana* and *Diplothrombium* having essentially no lateral arms on the posterior margin of the gnathosoma and with *Centrotrombidium* having only moderately developed arms here. The maximum development of these structures is found in *Lassenia*. Within this genus there is quite a bit of difference between the two known species, with *L. spinifera* having relatively longer posterolateral arms than *L. lasseni*.

Chelicerae

The form of the chelicerae in the Jonhstonianidae is fairly uniform, and is best seen in Figures 74 and 85. The tarsus or digitus mobilis is scythe-shaped with the dorsal margin ranging from nearly smooth to serrate (Fig. 7) to dentate (Fig. 247). The digitus fixus is membranous and shows no particular variants of generic importance. Perhaps the most significant variant in the form of the chelicerae is found in the tendency toward a downward flexure in the chelicerae of adults of the genus *Lassenia*. In *Lassenia lasseni* this flexure is only slightly developed, but in *L. spinifera* it is very pronounced (Figs. 200, 245). One very interesting bilateral anomaly was found in a single female of *Centrotrombidium distans* (Fig. 24) in which a typical seta and alveolus were found dorsally at the base of the digitus fixus. No other individuals of this species were found to have such a seta here, and certainly none of the other Johnstonianidae studied had a seta in this position, or anywhere on the chelicera. Such a seta is found at this point in many genera of *Eleutherengona*, however, and also in many of the Parasitiformes. The appearance of this seta in this anomalous individual not only suggests that the Johnstonianidae were derived from a group which did have a seta on the chelicera, but also raises the question why such a structure, apparently so irrevocably lost in the course of evolution of the group, should suddenly reappear as a bilateral variant in a single female of *Centrotrombidium distans*. Further details of this will be found under the description of the species.

Segmentation and General Form of the Palp

With a single exception the palpi of the Johnstonianidae are provided with five free segments. In larvae of *Lassenia lasseni* (Figs. 210, 213) there is a tendency toward the fusion of the femur and patella on the dorsal side;

this is not seen however in *L. scutellata* so that the character does not seem to have generic significance. In the adults the palpi are always distinctly five-segmented. The general form of the palpi in the adult is basically the same in all genera, slightly curved but essentially linear in dorsal view. The same is true of the larvae of all of the genera except *Lassenia*, in which the palpi are geniculate, owing to the expansion of the posterior or posterolateral aspect of the femur. Associated with this expansion of the femur, the trochanter is reduced to a narrow ring. The geniculate palpi of *Lassenia* larvae are suggestive of similar palpi which show up at other points within the terrestrial Parasitengona, and in these cases too it is interesting to note that the geniculate form is lost in the transition from larval to nymphal stages.

Fenestration of Trochanter of Palp

This is a characteristic which presently appears to be confined to the family Johnstonianidae. In the larva and adult of *Diplothrombium* and *Centrotrombidium* (Figs. 33, 61, 153, 179) there is a discrete oval window on the anterior (medial) aspect of the trochanter of the palp. This appears to be a portion of the cuticle which is considerably thinner and more transparent than the cuticle of the remainder of the trochanter. In *Johnstoniana* there is no trace of a fenestra. In *Lassenia* the situation is somewhat variable. In both of the known species the larva has a trochanter of very short length, probably associated with the geniculate form of the palp. In this there is no suggestion of a fenestra. In the adult of *L. lasseni* (Fig. 201) there is a well-developed fenestra, but the anterior margin is not closed off as it is in *Diplothrombium* and *Centrotrombidium*. Thus the trochanter has the appearance of being deeply incised on the anterior aspect. In *L. spinifera* (Fig. 239) the same condition is found, except that here the concavity is invaded by a distinct, although feeble extension of the cuticle of the femur.

The Palpal Tibia

The form of the tibia in the Johnstonianidae known to date is quite constant in the larva. In all species there is a heavy terminal seta which is unidentate in *Lassenia scutellata* and *Centrotrombidium distans*, but bidentate in the other four species for which larvae have been adequately described. The terminal setae have been given a number of names by workers in various divisions of the Parasitengona including "tibial claw, tibial spur," etc. While the name is not of paramount importance, it is well to keep in mind that this is not a claw, but nothing more nor less than a seta of unusual thickness, and it is preferable to refer to it as the terminal seta of the tibia. The term "claw" is a malapropism. In the larvae of all known species there are three normal setae behind the heavy spiniform terminal seta, and these may be either smooth or faintly pectinate.

In the adults of all known species, the terminal seta of the tibia is invariably unidentate. Moreover there is always a single subterminal spiniform seta which may be very close to the terminal seta as in *Lassenia* and *Diplothrombium micidium*, or may be removed from it by a distance greater than the diameter of the alveolus of the terminal seta as in *Johnstoniana* and *Diplothrombium monoense*. In *J. latiscuta* there is a heavy spine near the base of the subterminal spiniform seta. In some of the Trombidiidae there is also a *ctenidium* composed of several stout setae arranged in a regular series, but this structure is not present in any of the known Johnstonianidae.

Segmentation of the Legs of the Larvae

In both species of the genus *Lassenia* the femur is completely undivided so that there are only five free segments beyond the coxa. In *Johnstoniana latiscuta*, there is a distinct synarthrodial membrane on the ventral surface of the femur, but the dorsal sclerotized portion of the cuticle is continuous across the entire length of the femur (Figs. 87, 91, 93).

In both *Centrotrombidium* and *Diplothrombium* the basifemur and telofemur are completely separated by a flexible synarthrodial membrane. The femora of the adults of all species are divided.

Specialized Setae of the Appendages

Here it is well to digress a little in order to point out a difficult situation which exists in the nomenclature of the specialized setae of the appendages of the Parasitengona. In the United States the majority of the work in the terrestrial Parasitengona has been done in the Trombiculidae, by investigators whose major or even sole interest in the group was stimulated by the medical or general parasitological importance of these mites. In no case is there any published evidence that these workers have availed themselves of Grandjean's studies on the types of setae found on the appendages of mites in general including the Parasitengona. Grandjean's unexcelled contributions to the chaetotaxy of the Acari began in 1935 and have continued up to the present time. The major setal types were clearly elucidated and named prior to 1940. Grandjean's studies were cilmaxed in 1947 with the publication of his *Étude sur les Smarisidae* (1947) in which the broad outlines of the morphology of the various setal types on the appendages of the Parasitengona were laid down. This was one of the classics of modern acarology and it is incomprehensible that certain workers should have proposed a "standardized terminology" of the trombiculid mites, including the specialized setae, without a single reference to this or Grandjean's numerous other publications. It is to be hoped that acarologists generally will realize that it is definitely not in the best interest of acarology for any group of workers to set up a highly formalized and (by virtue of the number who have contributed) ostensibly authoritative system of terminology, either in complete ignorance or in complete disregard of the intensive work of others who have devoted many years of profound study to the morphology of the Acari. The Trombiculidae are no more than one very small segment of the Acari, and there is no reason why they should be treated differently from other groups, despite the medical importance of a few exceptional members of the family.

In his studies on the Johnstonianidae, the writer has followed the system of nomenclature proposed by Grandjean, first in 1935, and expanded in subsequent years. This will inevitably cause confusion to those familiar with only the terminology proposed by American workers (Wharton *et al.*, 1951). This is not done on the basis of priority, but with the knowledge that a choice must be made between two systems, plus the conviction, based on experience, that the older Grandjean nomenclature is more universally applicable, more fundamental, and, in the final analysis, more logical and comprehensible than the newer highly specialized terminology promulgated by investigators whose experience in the Acari is either primarily or entirely limited to immature stages in a single family.

The following table of equivalents is provided to help in the transposition from one system to the other.

Many examples could be cited to show the inevitable difficulties in the setal terminology which has sprung up during the past few years. One of these difficulties stems from the fact that the terminology has been evolved almost exclusively as an outgrowth of the describing of larvae and shows gross inconsistencies when an attempt is made to apply it to postlarval stages. A second is that related setae are often given quite different names, while some totally unrelated setae are given confusingly similar names.

For instance, the "subterminala" is a specialized seta found near the tip of the tarsus of leg I and the palp. In the adult the ontogenic descendants of the "subterminala" of the palpal tarsus are called "apical setae" or "apical nude setae." The morphological de-

Grandjean System, with Modifications Introduced in This Paper	*Terminology Proposed by Various Specialists in the Larval Trombiculidae*
solenidion$_1$ or s_1	spur of tarsus I
solenidion$_2$ or s_2	spur of tarsus II
solenidion$_3$ or s_3	microfemorala, microgenuala, microtibiala (in part)
solenidion$_4$ or s_4	microtibiala (in part)
solenidion of palpal tarsus	spur of palpal tarsus
dorsal eupathid of larval tarsi, or "eupathid at 0.71*d*" (etc.)	subterminala
distinventral eupathid of larval tarsi, or "eupathid at 0.92*pv*" (etc.)	pretarsala (a misnomer)
eupathidia of various segments of adult legs	(no acceptable equivalent)
companion seta of dorsal eupathid of larva	parasubterminala
companion seta of s_1 or s_2 of larva	(no equivalent)
companion seta of s_4 of larva	(no equivalent)
eupathidia of palpal tarsus of larva	subterminala of palpal tarsus of larva
eupathidia of palpal tarsus of adult	apical setae or apical nude setae
supracoxal setae	(no equivalent)
vestigial setae	microgenuala, microtibiala
famulus$_1$	microspur of tarsus I
famulus$_2$	microspur of tarsus II
bothridia	mastifemorala, mastitibiala, mastitarsala

scendants of the "subterminala" of the tarsi of the legs are simply called "nude setae" in the few cases in which they have been mentioned. "Nude setae" is apparently a catch-all category which includes famuli, solenidia, eupathidia, vestigial setae, and occasional normal setae which lack barbs. What is equally remarkable is that setae which are obviously morphological equivalents of the larval "subterminala" show up on segments as far back as the telofemur in adults. The term "subterminala" is therefore totally inappropriate to designate these setae, while the name "nude setae" is ambiguous. These are all eupathidia, and that term can be applied to these setae whether they are in larva or adult, on palp or leg, on tarsus, tibia, patella or telofemur. The "pretarsala" is another eupathid, but it is not on the pretarsus, and moreover its ontogenic counterparts in the adult are frequently indistinguishable from those of the "subterminala." The eupathidia are a particular type of seta found in a variety of places, and it seems unnecessary to apply special names to them.

The "genuala" and "tibiala" are both solenidia, and nearly all "tibiala" are structurally identical with all "genuala." Why, then, should these be given different names, just because they are on different segments of the legs? Why not also apply separate names to the normal setae found on the separate segments of the legs? It can also be pointed out that certain of the larval "tibiala" have counterparts which appear on the tarsus of the adult. The "spurs" are also solenidia, although differing structurally from the other solenidia of the legs. Giving the various types of solenidia different names, confusingly parallel in construction in some cases to the names of entirely different types of setae (femorala, genuala, tibiala, microtibiala, microgenuala, microtarsala, subterminala, pretarsala) complicates the picture unnecessarily. What is worse, it obscures the fundamental relationships and true differences between the setal types. These have been very adequately outlined by Grandjean, whose works are to be recommended most highly to any who have not yet read them.

During the course of the present studies it was found necessary to elaborate somewhat upon the solenidial classification in the Parasitengona. The Johnstonianidae, possibly more than any other family, show clearly the multiplicity of form of these setae, but at the

same time they also emphasize the essential unity of the various types. This will be more fully treated below.

The Solenidia of the Legs

The terrestrial Parasitengona are remarkable for the variety of solenidia developed on the legs. These must have considerable physiological, evolutionary and systematic significance, although it will require many years of work before these are understood. At the present time there are few unequivocal statements which can be made regarding the form and distribution of the various types, because of the complexity of study, and the lack of comparative studies in the several families. However, the most significant findings that have emerged from the present study are outlined here to provide at least a tentative beginning toward the eventual comprehensive understanding of the morphology of these important organs. In all cases the statements should be interpreted as applying most immediately to the Johnstonianidae, although exploratory studies in other families show clearly that their applicability extends far beyond the family momentarily under consideration.

1. The several types of solenidia are constant within a given genus. Interspecific variations are found in the numbers of a given type on specific segments of the legs, or differences in the position of certain highly characteristic types, or in minor but constant differences in form of a single type.

2. All species studied have at least three types of solenidia, while most have four. A decrease in number of types comes about through convergence of form rather than through deletion of one or another group of solenidia.

3. The different types of solenidia are recognizable in larval, nymphal and adult stages, although some apparent cases of divergence or convergence in form of two similar types have been observed in the transition from larva to adult.

4. As a general rule the solenidia of tarsi I and II of the larvae are different from each other and from the solenidia of the more proximal segments of the legs. Tarsus III does not possess solenidia in the larvae of the Johnstonianidae. Tarsi I and II in the larva always bear a single dorsal solenidion, usually without, rarely with a companion seta. The tarsal solenidia are thicker and more strongly marked with spiral or annular structure than those of the more proximal segments.

5. For purposes of convenience in differentiating the types and brevity in designating the types, the solenidia of tarsi I and II of the larvae and their ontogenic descendants in nymphs and adults, where these can be distinguished, will be designated solenidia$_1$ and solenidia$_2$, or s_1 and s_2 respectively. Where s_1 and s_2 cannot be differentiated this will be interpreted as a convergence in form so that s_1 and s_2 are indistinguishable. The reader should recognize that this is not the only interpretation that is available, but it should be equally apparent that if a different sequence of symbols is used each time a decrease in solenidial types is observed, the description of this change becomes unduly difficult. It is far simpler to utilize a single sequence of symbols which is applicable to the majority of cases and to fit observed exceptions to this rather than to evolve a new system to fit each particular variation. Further justification for this is found in the fact that the larvae of all species of Johnstonianidae studied so far, as well as all species of Trombidiidae and Trombiculidae which have been checked, have four types of solenidia on the legs which can be differentiated by either form or position, or usually both. The apparent reductions in solenidial types which have been observed to date consist entirely of convergences in setal types in the development from larva to adult.

6. The designation solenidion$_3$ or s_3 will be reserved for the type found on the proximal segments of the legs, with the exception of s_4 (see below). Even in cases in which s_1 and s_2 might be indistinguishable morphologic-

ally, so that they effectively comprise a single type, the designation s_3 will still be applied as indicated here, for the reason explained immediately above. Solenidia$_3$ are generally small, very slender, usually but not always lacking internal structure, and are probably invariably the most numerous type in both larval and postlarval stages.

7. In the larvae of all genera studied to date, a fourth type of solenidion is found dorsally on tibia I and will be designated solenidion$_4$ or s_4. This is a little larger than s_3 and typically shows some degree of internal structure. It may be intermediate in size to s_3 and s_1, and usually the distinction between these is considerably more difficult to appreciate in the adult than in the larva. The identification of s_4 is also confused by those cases in which a solenidion very similar to s_1 is found on tibia I in the position normally occupied by s_4. This is true of *Lassenia*, new genus, in which one distidorsal seta of tibia I has a companion seta and is of the same form as s_1. This might be interpreted either as a case in which s_1 is found on the tibia, or, as the writer has done, a case in which there is a strong convergence between s_1 and s_4. The situation is in no way simplified by the fact that throughout the protonymphal and deutonymphal instars of *Lassenia* there is a progressive diminution of this seta so that in the adult apparently only one type of solenidion can be found on tibia I with any degree of certainty—namely s_3.

8. As can be seen from the foregoing, the differences between solenidial types may be very marked, or there may be convergences which make interpretation of types exceedingly complex at times. However, we can only go so far in simplifying a complex situation, and perhaps the more surprising thing would be to find that all patterns of solenidial variation in the Johnstonianidae or the terrestrial Parasitengona in general could be smoothly fitted into a single scheme. If we fail to achieve this, we may yet succeed, if in failing we discover the reason for doing so.

The Johnstonianidae are a very fortunate group for studying the morphology of the solenidia, because in most genera the four types can be recognized not only in the larva but in the adult as well. This is especially so since s_2 in *Centrotrombidium*, *Diplothrombium*, and *Johnstoniana*, are of very unusual form and readily distinguishable from s_1 and s_4. In *Lassenia* larvae, s_1 and s_2 are of similar form and size, differing chiefly in the presence of a companion seta at the base of s_1. However, the companion seta is never retained in the postlarval instars, so this difference cannot be utilized in differentiating the two types of solenidia in the nymphs and adults. Consequently in this genus it is all but impossible to differentiate between s_1 and s_2 in the adult; moreover this situation extends to s_4 as well, as pointed out above.

One interesting feature of s_2 is that this type, while it appears first on tarsus II of the larva, is actually more abundant on tarsus I in the adult than it is on tarsus II. In other words they arise *de novo* on tarsus I in the postlarval stages, and in greater numbers there than in the site at which s_2 originally appeared in the larva. This is true in all genera (except possibly *Lassenia* in which the true state of affairs has not been ascertained because of the convergence in solenidial types in the postlarval stages).

The Eupathidia of the Legs of the Larva

Each of the four genera studied by the writer has a characteristic arrangement of the larval eupathidia. In all genera, the eupathidia are confined to the tarsi, and in all cases tarsus I has two eupathidia. Variations are found in the number of eupathidia on II and III, and in the presence or absence of companion setae. Both *Centrotrombidium* and *Johnstoniana* have eupathidial formulae of (2–1–0), but only in *Johnstoniana* is there a companion seta at the base of the dorsal eupathid. *Diplothrombium* has a formula of (2–1–0) in both species seen by the writer, but there is no companion seta with any of the eupathidia. In the two

species of *Lassenia* known in the larval stage, the eupathidial formula is (2–2–1), and the dorsal eupathid of both tarsi I and II in both species has a basal companion seta. Only in *Lassenia* is there a eupathid on tarsus III, and this is subterminal in position.

The Eupathidia of the Legs of the Adult

Here we find differences in the distribution of the eupathidia on the various segments of the legs, with *Centrotrombidium* having the eupathidia confined to the tarsi, and tarsus IV typically with only one eupathid. In the other three genera, eupathidia are found on all segments beyond the basifemur. In all genera but *Lassenia* there is a subterminal eupathid on tarsus IV. In *Centrotrombidium* this lies at about 0.85*a* to *av*, in *Diplothrombium* at 0.90 to 0.95*v* and in *Johnstoniana* at 0.91*pv*. Specific differences are found in the distribution of the eupathidia on the individual segments of the legs. One interesting example is found in the genus *Lassenia* in which ventral eupathidia are found on the telofemur, patella and tibia of leg I, whereas in *L. lasseni* all of the eupathidia are dorsal or marginal in position.

The Companion Setae

Companion setae are found only in the larvae of some genera, and are seemingly universally absent in the postlarval stages of all of the Parasitengona. Neither *Centrotrombidium* nor *Diplothrombium* has any companion setae in either larval or postlarval stages. *Johnstoniana* larvae have one companion seta associated with the dorsal eupathid of tarsus I, while in *Lassenia* there are four companion setae. These are associated with s_4 of tibia I, s_1 of tarsus I, and the dorsal eupathid of both tarsi I and II.

The Famulus

The famulus is the most constant of all the specialized setae in the Johnstonianidae. A famulus is present on both tarsi I and II in all genera, in both larval and adult stages. Variations in the position of the famulus often provide very useful specific characters (as in *Centrotrombidium*, for example), although a noticeable degree of variation in the position of the famulus is observed in some species. In others the famulus appears to show extremely little variation in position.

The Supracoxal Setae

The situation here is not certain, although it is probable that these are not as variable in their number and distribution as are the setae on the ventral surface of the coxa. Supracoxal setae, when present, are found both on the dorsal surface of the coxal portion of the gnathosoma, and on the dorsal surface of the coxae of leg I. This appears to be a general rule in the Parasitengona. In the Johnstonianidae, supracoxal setae are absent in all but the genus *Lassenia*. In the known species of this genus supracoxal setae are present on the dorsal surface of the gnathosoma as well as on the dorsal surface of coxa I. The distribution of supracoxal setae in the adult is always the same as in the larva so far as is known.

The Vestigial Setae

These are the small spikelike setae at the distidorsal end of the patella or tibia of legs I and II (Figs. 91, 194, 215). The distribution of these very often follows that of the supracoxal setae, that is, when the latter are present vestigial setae are also present. This is true in both *Centrotrombidium* and *Diplothrombium* in which none of the described species has either supracoxal or vestigial setae. In *Lassenia lasseni* and *L. spinifera*, vestigial setae are found on patella I and II and on tibia I; likewise supracoxal setae are present on the palpi and leg I. In *Johnstoniana latiscuta* an intermediate condition is found; for although there are no supracoxal setae, vestigial setae are present on patella I and II but are absent from all tibiae. As in the case of the supracoxal setae the distribution of the vestigial setae is identical in larva and adult in all species studied. The distribution of the supracoxal and vestigial

DISTRIBUTION OF COXAL, SUPRACOXAL AND VESTIGIAL SETAE (LARVAE)

	No. Coxal Setae	Supracoxal Setae		Vestigial Setae			
		Palpi	I	I		II	
				pa	ti	pa	ti
J. latiscuta	2–1–1	0	0	1	0	1	0
D. monoense	2–1–1	0	0	0	0	0	0
D. cascadense	2–1–1	0	0	0	0	0	0
C. distans	2–1–1	0	0	0	0	0	0
L. lasseni	2–2–3	1	1	1	1	1	0
L. scutellata	2–1–2	1	1	1	1	1	0

setae in the larvae of the known Johnstonianidae is summarized in the table given above. Although this table is based on the larvae, the figures would be identical for the adults except for the number of coxal setae.

The Specialized Setae of the Palpal Tarsus of the Larva

One constant feature in the chaetotaxy of the palpal tarsus of the larva is the presence of a single solenidion on the posterior aspect of the basal one-third of the segment. The tarsal eupathidia exhibit one interesting variant. In both species of *Lassenia* these are of typical eupathidiform structure, tubular throughout, and relatively thin-walled. Moreover, the terminal eupathid is always at the very end of the segment (Fig. 253). In the other three genera, the end of the tarsus always extends beyond the insertion of the most distal seta. Moreover, none of the tarsal setae in larvae of these three genera are typically eupathidiform, although it may be presumed that some of the terminal ones are homologous with the typical eupathidia of *Lassenia*. These subterminal setae are strongly hemipectinate, and in *Centrotrombidium distans*, the one nearest the end of the segment is also flattened and expanded (Figs. 28, 29, 92, 176).

The Specialized Setae of the Palpal Tarsus of the Adult

While in the larva the solenidion on the posterior surface of the palpal tarsus is always in the basal one-half or one-third of the segment, in the adult there is a strong tendency for the solenidion to be displaced toward the distal end. In *Centrotrombidium* it is found at roughly 0.3*p*, in *Diplothrombium* at approximately 0.5*p*, and in *Johnstoniana* and *Lassenia* at approximately 0.8 to 0.9*p*. Paralleling the displacement of the solenidion is an increase in number of eupathidia. Thus, in *Centrotrombidium* there are only 2 terminal eupathidia, but in *Diplothrombium* there are 3 to 5, in *Johnstoniana* about 6, and in *Lassenia* from 6 to 15 depending upon the species and the individual. These trends are not entirely associated with size for although *Diplothrombium micidium* is smaller than *D. monoense*, the number of eupathidia on the tarsus of the palp is greater. Also the tarsus of the palp of *Johnstoniana latiscuta* is larger than that of *Lassenia spinifera*, yet there are only about half as many eupathidia.

DESCRIPTIONS AND KEYS

JOHNSTONIANIDAE new family

DIAGNOSIS: Adults with genital and paragenital sclerites about equally developed, and with three pairs of genital acetabula. Scutum with two pairs of typical sensilla, or with anterior pair greatly modified to absent. Scutum frequently with an anterior spine. Hysterosomal setae typically smooth, borne on individual sclerites. Chelicerae as in Trombidiidae, with base, movable tarsus, and a delicate dorsal membrane. Palpal tibia without ctenidium, with only the one terminal and one subterminal spiniform setae. Anterior wall of palpal trochanter often fenestrated.

Larvae also with one to two pairs of sensilla on the scutum. Dorsum with setae borne

individually on relatively large sclerites. Intercoxal area with a single pair of setae between III, or devoid of setae; urpore present. Either three or two pairs of rostral setae. Palpal tarsus simple, cylindrical or fusiform. Larvae self-detaching parasites of insects, living in damp to very wet places, and typically with relatively restricted temperature tolerances.

REMARKS: Not all of the variants of the morphological characters of the Parasitengona can be readily utilized in a key, but the more convenient ones are included here. It is interesting that the number of characters available in the larva considerably exceeds the number available in the adult. Actually the discrepancy is not as great as would appear at first glance, since some adult characters are omitted simply because of difficulties in interpreting them.

It appears possible that the Johnstonianidae as defined here will require further reorganization as more forms become known from other parts of the world. At present it is quite evident that there are two distinct groups of genera, the first including *Centrotrombidium*, *Diplothrombium*, *Johnstoniana*, and provisionally *Hirstithrombium* (Johnstonianinae Thor 1935). The second includes *Lasenia* new genus, *Polydiscia* Methlagl 1928, and provisionally *Crossothrombium* Womersley 1939 (*LASSENIINAE* new subfamily). The principal structural differences between the genera are summarized in the formula keys given below.

FORMULA KEY TO GENERA OF

JOHNSTONIANIDAE
Based on Adults

1a. Anterior sensilla present, similar in form to the posterior sensilla, and at least one-half as long as the posterior sensilla (Figs. 70, 160).

1b. Anterior sensilla present, but considerably modified, less than one-half as long as the posterior sensilla (Figs. 183, 232).

1c. Anterior sensilla absent; scutum greatly reduced, bearing a single pair of sensilla, anterior to which is a single pair of normal setae (Fig. 4).

2a. Pregenital tubercle absent.

2b. Pregenital tubercle present (Figs. 185, 233).

3a. Anal sclerites present (Figs. 18, 105).

3b. Anus surrounded only by membranous cuticle containing setae, but no sclerites (Fig. 68).

4a. Palpal trochanter with anterior surface containing a distinct oval fenestra (Fig. 61).

4b. Distal margin of anterior wall of trochanter deeply incised, but the fenestra is not completely circumscribed (Fig. 201).

4c. Anterior wall of trochanter with no trace of a fenestra (Fig. 69).

5a. Eupathidia present on leg segments other than the tarsi.

5b. Eupathidia confined to the tarsi.

6a. Supracoxal setae absent from gnathosoma and coxae I.

6b. Supracoxal setae present on gnathosoma and coxa I.

7a. Vestigial setae absent from patella and tibia of all legs.

7b. Vestigial setae present only on patella I and II, absent from tibiae.

7c. Vestigial setae present on patella I and II, and tibia I; absent from tibia II.

8a. Solenidia$_2$ of tarsus I clavate, markedly different in form from s$_1$.

8b. Solenidia$_1$ and s$_2$ of tarsus I differing primarily in size; no sharp differences in form.

FORMULA KEY TO GENERA OF

JOHNSTONIANIDAE
Based on Larvae

1a. Scutum with four pairs of setae (two pairs of normal setae plus two pairs of sensilla).

1b. Scutum with two pairs of setae (one pair of normal setae plus one pair of sensilla).

DISTRIBUTION OF VARIANTS

1	2	3	4	5	6	7	8	
								JOHNSTONIANINAE
a	a	b	c	a	a	b	a	**Johnstoniana**
a	a	a	a	a	a	a	a	**Diplothrombium**
c	a	a	a	b	a	a	a	**Centrotrombidium**
?	?	?	?	?	?	?	?	**Hirstithrombium**
								LASSENIINAE
b	b	a	b	a	b	c	b	**Lassenia**
?	?	?	?	?	?	?	?	**Polydiscia**
?	?	?	?	?	?	?	?	**Crossothrombium**

2a. Anal sclerites absent.

2b. Anal sclerites present, usually with one or more pairs of setae.

3a. Protorostral, deutorostral and tritorostral setae all present and setiform or spiniform (deutorostrals often concealed under velum).

3b. Deutorostral setae absent or reduced to extremely minute vestiges, tip of rostrum with only two pairs of setae.

4a. Palpal trochanter with anterior wall fenestrated.

4b. Anterior wall of palpal trochanter not fenestrated.

5a. Terminal seta of palpal tarsus eupathidiform (hollow, thin-walled, etc.).

5b. Terminal seta of palpal tarsus not typically eupathidiform, but flattened, strongly serrate, or otherwise modified.

6a. Tarsal eupathidia 2–1–0.

6b. Tarsal eupathidia 2–1–1.

6c. Tarsal eupathidia 2–2–1.

7a. Dorsal eupathid of tarsus I with companion seta.

7b. Dorsal eupathid of tarsus I without companion seta.

8a. Dorsal eupathid of tarsus II present, with companion seta.

8b. Dorsal eupathid of tarsus II absent.

9a. Solenidion$_4$ of tibia I with companion seta.

9b. Solenidion$_4$ of tibia I without companion seta.

10a. Coxal setae with formula 2–1–1.

b. Coxal setae with formula 2–1–2 or 2–2–3.

11a. Supracoxal setae absent on gnathosoma and coxae I.

b. Supracoxal setae present on gnathosoma and coxae I.

12a. Vestigial setae absent from patella and tibia of all legs.

b. Vestigial setae present on patella I and II only, absent from tibiae.

c. Vestigial setae present on patella I and II and tibia I; absent from tibia I.

13a. Femora I–III of all legs completely divided into basifemur and telofemur (six free segments beyond the coxae).

b. Femora I–III undivided (only five segments beyond the coxae).

c. Femora I-III partially divided, the synarthrodial membrane well formed ventrally, but absent dorsally (Figs. 87, 91, 93).

14a. Tarsi with two unequal claws on all legs, the anterior claw more erect than the posterior.

b. Tarsi with three claws on all legs, the anterior and posterior claws equal, the median (axial) claw more slender, erect.

15a. Intercoxal area with a pair of setae between III.

b. Intercoxal area without a pair of setae between III.

JOHNSTONIANINAE Thor 1935

DIAGNOSIS: Adults with either one or two pairs of sensilla on scutum. Pregenital tubercle absent. Solenidia$_2$ typically clavate, differing appreciably from s$_1$. Supracoxal setae absent from gnathosoma and coxa I in both larva and adult. Larvae without anal sclerites; usually with a single pair of setae in the inter-

DISTRIBUTION OF VARIANTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
															JOHNSTONIANINAE
a	a	b	b	b	a	a	b	b	a	a	b	c	a	?	Johnstoniana
a	a	b	a	b	a	b	b	b	a	a	a	a	a	a	Diplothrombium
b	a	b	a	b	a	b	b	b	a	a	a	a	a	a	Centrotrombidium
?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	Hirstithrombium
															LASSENIINAE
a	b	a	b	a	c	a	a	a	b	b	c	b	b	b	Lassenia
a	b	?	?	a	?	?	?	?	b	?	?	a	b	b	Polydiscia
?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	Crossothrombium

coxal area between coxae III. Deutorostral setae absent; terminal seta of palpal tarsus not eupathidiform. Tarsi each with two claws.

Centrotrombidium Kramer 1896

ADULT: Length of idiosoma 500 to 1200 μ in known species. Scutum of both adult and larva bearing a single pair of clavate sensilla and anterior to these, a single pair of elongate normal setae; anterior sensilla absent. Anterior end of scutum drawn out into a long spine. Ocular plates bearing two refractile corneae each, or one refractile cornea and a non-refractile lobe. Dorsal hysterosomal setae borne on individual sclerites, no large plates present. Anal sclerites well developed. Supracoxal setae of legs and gnathosoma and vestigial setae of legs completely absent in both larva and adult. Trochanter of palp with anterior wall fenestrated in both larva and adult. Palpal tibia with a single subterminal spiniform seta; tarsus with one solenidion and usually only two eupathidia. Solenidia of legs of four recognizably different types; tarsi I and II with one or more clavate solenidia$_2$ on posterior aspect. Famulus of tarsi I and II located in distal one-fifth of segment, on posterior membrane of claw fossa. Eupathidia of legs confined to tarsi.

LARVA: In addition to those which are common to both larva and adult, the larva has the following characteristics. Ocular plates distinctly bicorneate. Anal sclerites absent. Velum small, simple; deutorostral setae absent, or represented by vestigial structures. Base of gnathosoma without posterorostral setae. Femur of all legs divided. A single clavate solenidion$_2$ on tarsus II, s_1 of tarsus I curved, rodlike. Tarsus of all legs with two simple, smooth claws.

REMARKS: At present only five or six species are known, including the three new ones described here. *C. schneideri* Kramer 1896 is rather widely distributed in Europe, and *C. australasiae* is known from Australia. *C. miselum* (Berlese), from Mexico, is provisionally placed in this genus. The genus is probably cosmopolitan. The adults are small, brown mites, rather inconspicuous, found crawling over wet ground along the margins of streams and ponds. The writer has also collected them in estuarine habitats. The larvae are probably parasitic upon various small arthropods but nothing is known about host relationships. The known species can be separated on the basis of the diagnostic formulae given below.

FORMULA KEY TO ADULTS OF CENTROTROMBIDIUM

1a. Sensilla of scutum with distal portion nearly spherical, length of stalk less than twice the diameter of the sphere, and less than the distance between the sensillar alveoli.

1b. Distal portion of sensillum clavate or pyriform, stalk very long, at least twice as long as the expanded tip, and considerably longer than the distance between the alveoli.

1c. Sensilla not swollen, but slender through, out.

2a. Dorsal hysterosomal setae relatively long-slender, tapering uniformly to a very fine point (Figs. 19, 22).

2b. Dorsal hysterosomal setae appreciably stouter and of more nearly uniform diameter throughout, reaching only a little beyond the margin of the setigerous sclerites (Fig. 64).
3a. Ocular plates with only one distinct cornea, plus a non-refractile posterior lobe (Fig. 53).
3b. Ocular plates with two distinct corneae.
4a. Tarsus I with only two (exceptionally 1 or 3) clavate solenidia$_3$ on posterior membrane of claw fossa (Fig. 48).
4b. Tarsus I typically with more than two clavate solenidia here.
5a. Famulus of tarsus II very close to alveolus of clavate solenidion$_3$, removed from it by a distance no greater than the length of the solenidion, and with no other setal alveoli in the intervening distance (Fig. 49).
5b. Famulus of tarsus II removed from alveolus of clavate solenidion$_3$ by a distance greater than the length of the solenidion; one or two normal setae in intervening distance (Figs. 6, 8).
6. Range in idiosomal length, by sex, where known.

Since the larva of only *C. distans* is known, no key to larvae can be given. The above key does not include all the characters of probable specific value in the genus, but they are the more important ones. Others include the difference in form of the posterior end of the scutum, which is important in differentiating *C. distans* and *C. approximatum*, but this is difficult to state in words. Womersley (1942, p. 171, fig. 2c) showed no anterior spine on the scutum of *C. australasiae* Womersley 1942. It is likely that this was drawn from an undissected specimen, and in such specimens the scutal spine often projects straight downward so that it cannot be seen in dorsal view. Whether or not this is the case in Womersley's species is not known, but the possibility should certainly be kept in mind upon comparing this with other species of the genus.

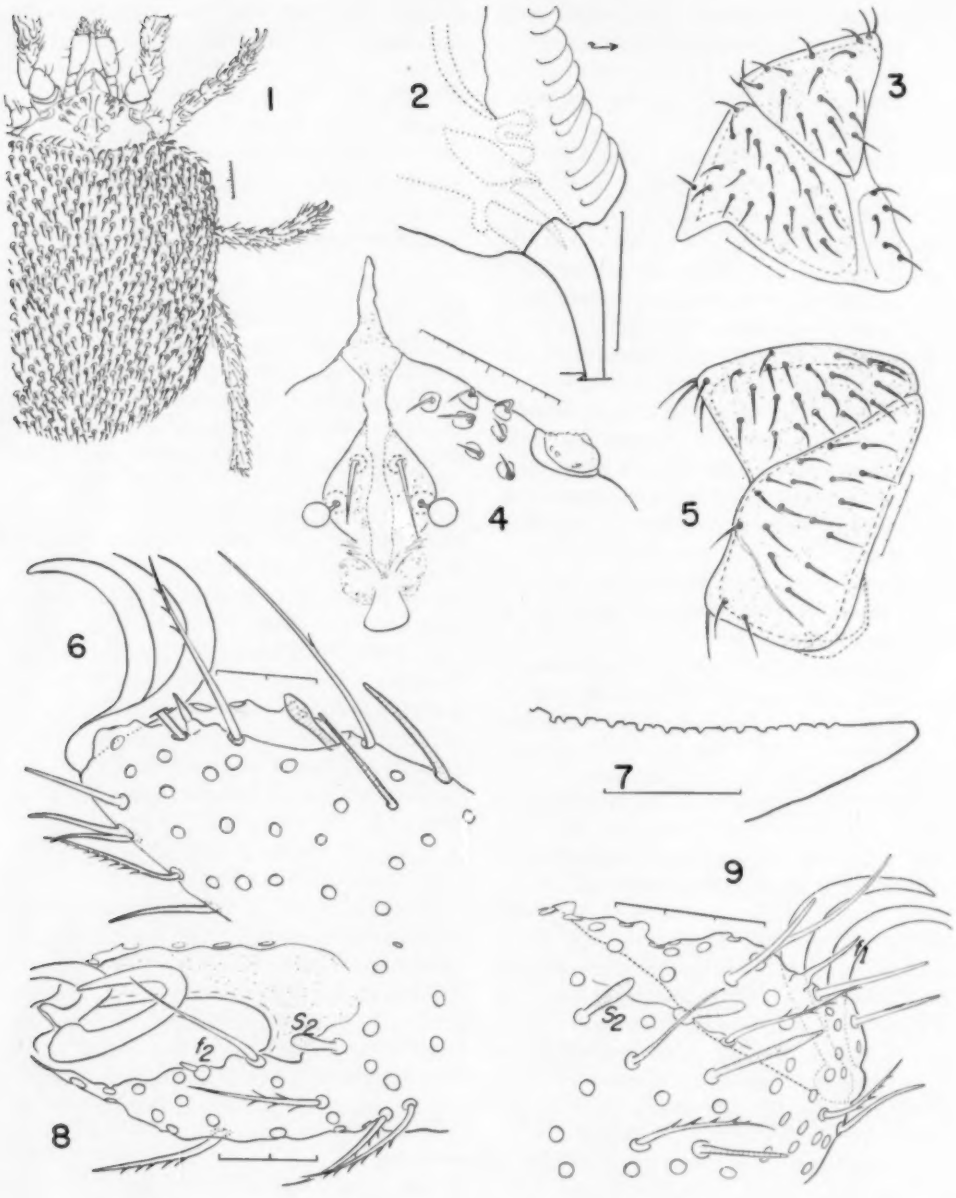
Centrotrombidium distans new species

FEMALE: Idiosoma (Fig. 1) 897–988 μ long, 702–728 μ wide (two ovigerous specimens). Scutum (Fig. 4) drawn out into a long anterior spine, and with a single pair of capitate sensilla, anterior to which is a pair of stout, long, smooth to faintly roughened setae; anterior sensilla absent. Crista metopica extending for most of length of scutum. Ocular plates very small, bearing only one prominent cornea (the anterior one) and an angular process (Fig. 25). Cuticle of ocular plate outside of cornea minutely tuberculate. Propodosoma between ocular plate and scutum with about seven setae, all of which lie at or anterior to the level of the sensilla. Dorsal and lateral body setae (Fig. 19) arising from alveoli borne on prominent raised sclerites, shaft sharply deflexed near base of seta. Membranous cuticle between sclerites with no visible markings except for a few faint parallel striae seen in some parts of the body. Subcuticular reticular layer a network of fine fibrils.

Coxae I and II (Fig. 3) with only about 20 to 25 smooth setae each; pars medialis coxae with about 5 setae; supracoxal seta absent. One small apodeme behind coxa II, very feebly developed. Coxae III and IV also with about 20 to 25 setae (Fig. 5). Ventral body setae like those of dorsal and lateral surfaces. Genital sclerites (Fig. 10) with 9 to 12 smooth

DISTRIBUTION OF VARIANTS

1	2	3	4	5	6	
a	a	a	a	b	♀ 897– 988 μ	***distans*** n. sp.
a	a	a	a	a	♀ 988–1092 μ	***approximatum*** n. sp.
a	a	a*b*	a	b	♀ 962 μ	***badroseta*** n. sp.
a	a	b	?	?	525 μ	**schneideri** Kramer 1896
c	b?	?	?	?	800 μ	**misellum** (Berl.) 1918
b	?	b	b?	?	1020 μ	**australasiae** Wom. 1942



FIGS. 1 – 9. *Centrotrombidium distans* n. sp.: 1, dorsum, female; 2, tip of rostrum showing tritorostral seta and presumed deutorostral rudiment; 3, coxae I and II, female; 4, propodosoma, female; 5, coxae III and IV, female; 6, tarsus I, female, posterior; 7, cheliceral tarsus, female; 8, tarsus II, male, posterodorsal; 9, tarsus I, posterior, female.

setae in a single row, paragenital sclerites with 15 to 18 smooth setae. Three pairs of genital acetabula. Anus (Fig. 18) flanked by two crescentic sclerites bearing 6 to 8 smooth setae each. Base of gnathosoma and rostrum as described for *C. approximatum*, new species. Chelicerae also as in the following species, except that the teeth on the chelicerae appear to be significantly heavier (compare Figs. 7, 52). In the holotype female there was a seta at the base of the dorsal membrane of one chelicera, and an indication of at least the alveolus and a short shaft on the other chelicera (Fig. 24). However, no such seta could be found on the male collected at the same locality, nor on either the male or female of *C. approximatum*. This is an interesting anomaly, suggestive of the condition normally found in the Parasitiformes, and many of the Eleutherengona in which a seta is frequently found in this position in normal individuals. Number, form, and arrangement of setae on all segments of the palp identical with that of the holotype of *C. approximatum* (Figs. 58, 59, 61).

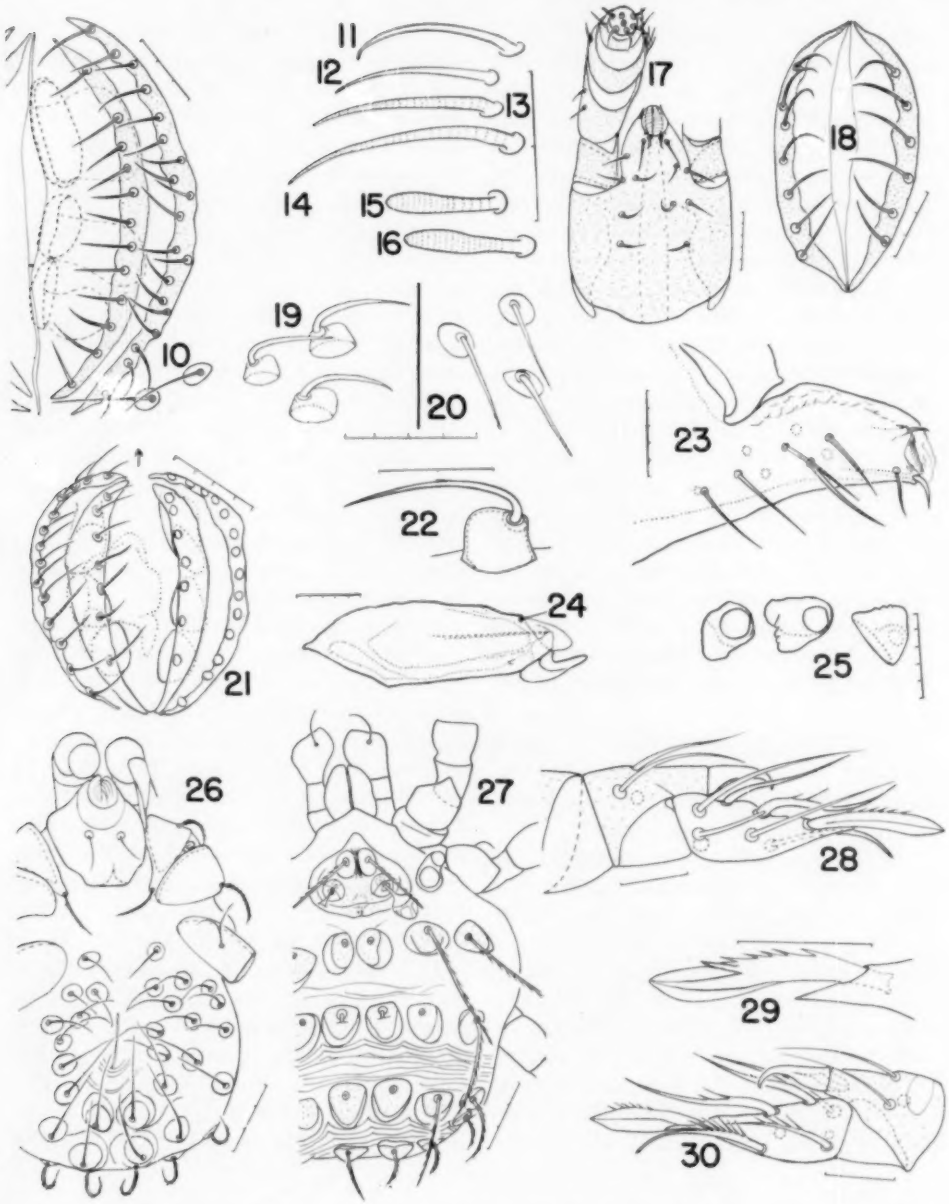
Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae, m = many).

Vestigial setae absent on all segments of all legs, and eupathidia present only on the tarsi. Tarsus I greatly swollen, height/length 0.50 to 0.56 (two specimens), claw fossa beginning at 0.64 to 0.65 and extending to end of tarsus. Typically with two clavate solenidia$_2$ on the posterior aspect of tarsus I, the first of these at about 0.65 to 0.68*p*, the second at 0.70 to 0.79*p* (Fig. 9). In some cases s_2 have a faintly annulate structure; in others they appear smooth. The peculiar seta with the fusiform distal half seen disti-ventrally to the solenidia$_2$ in Figure 9 is an anomaly. Famulus spikelike, located at 0.90 to 0.93*pd*, arising from a distinctly vesicular alveolus. Tarsus I also with numerous s_1 and eupathidia, the latter extending around the ventral and distal margin of the tarsus from 0.43*v* to 0.80*d*. The eupathidia have a characteristically geniculate terminal filament visible under oil (not shown in figure). Some tarsi I have only one or as many as three solenidia$_2$, but two is the normal number. Tarsus II with a single clavate solenidion$_2$ near the basal end of the claw fossa (Figs. 6, 8) at about 0.64*pd*, and a peglike famulus at 0.85*pd*, borne on a distinctly vesicular alveolus. Tarsi III and IV with two and one eupathidia each in the material studied. S_2 highly distinctive (Figs. 15, 16), but s_4 (Fig. 13) occasionally intergrading with s_1 and s_3 so that it is difficult to assign certain setae to one or another type.

MALE: Body 754 to 858 μ long (average 806 μ, three specimens). In general resembling female except for structure of genital area (Fig. 21). Genital sclerites with 6 to 9 setae in a single row, paragenital sclerites with 12 to 18 setae in a single row. Three pairs of genital acetabula. An interior circlet of about 12 setae can be seen in some favorable specimens, but are not shown in the figure. Penis very small, inconspicuous. Anal sclerites as in female.

LARVA: Idiosoma (Fig. 27) 152–167 μ long. Scutum somewhat triangular, greatly reduced (Fig. 32), bearing only the posterior pair of sensilla, anterior to which is a pair of stiff, hemipectinate setae. Between the latter a very short, rudimentary crista metopica. Sensilla capitate, the spherical distal portion crumpled in some mounted specimens (artifact). Ocular

	tr	bf	tf	pa		ti		ta					
	n	n	s_3	s_2	s_4	s_3	s_4	s_1	s_2	s_3	s_4	e	f
I	4–5	15	6–10	31	2–3	28–35	3	15	2	0	4?	m	1
II	4	11	3–7	16	0	17	2	6–8	1	0	0	2	1
III	5	11	3–4	8–12	0	10–14	0	0	0	0	2	2	0
IV	8	9	4	9	0	8	0	0	0	0	1	1	0



FIGS. 10–30. *Centrotrombidium distans* n. sp.: 10, genital opening, female; 11, solenidion$_3$, patella I; 12, s_3, femur II; 13, s_4, tarsus II; 14, s_1, tarsus I; 15, s_2, tarsus I; 16, s_2, tarsus II (all from female); 17, gnathosoma, female; 18, anus, female; 19, dorsal hysterosomal setae, side view; 20, same, top view; 21, genital area, male; 22, marginal body seta, female; 23, rostrum, female, lateral; 24, chelicera showing abnormal seta, female; 25, ocular plates, female, various aspects; 26, venter, larva; 27, dorsum, larva; 28, palpal tibia and tarsus, larva, posterior; 29, terminal seta of palpal tarsus, larva; 30, tibia and tarsus of palp, larva, anterior.

plates bicorneate, simple in form. Dorsal and marginal setae numbering 24 in four rows of 6 each, each seta hemipectinate and borne on a separate sclerite.

Coxa I with one pectinate seta laterally and another in the medial angle (Fig. 26); supracoxal seta absent. Medial portion of coxa I very indistinct, differentiated only by the absence of striae. Coxa III with a single bifurcate seta. Intercoxal area with a single pair of smooth setae, inserted on a pair of smooth, slender sclerites between III. Fifteen postcoxal setae on each side, borne on individual sclerites surrounding the anus.

Base of gnathosoma (Fig. 45) with one pair of simple smooth setae (tritorostrals?), deutorostral setae vestigial, visible only under oil immersion; protorostrals small, simple. Velum oval in outline, reticular in appearance. Chelicerae small, compact (Fig. 44), digitus fixus very small, pointed, tarsus not in favorable position for study, but apparently with one dorsal tooth proximal to the tip. Palpi (Fig. 33) five-segmented, trochanter lacking setae, femur and patella each with a single dorsal seta with a few barbs. Palpal tibia with three simple setae and the unidentate spurlike seta which is inserted in the end of a truncate projection of the tibia. Palpal tarsus (Figs. 28, 30) with solenidion at 0.10*p*, with only the faintest indication of annuli. A curved, hemipectinate seta at 0.50*av* which extends along ventral margin of tarsus, somewhat obscuring the very fine tip. A very heavy seta at 0.71*d*, terminal portion flattened, spatulate, the margin pectinate. Tip of tarsus forming a sharp pointed spine extending well beyond insertion of spatulate seta. Otherwise with five setae which are smooth, or which bear from one to four pectinations; typical eupathidia absent.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae).

Tibia I with one s_2 and one s_4 dorsally, II and III each with one s_3, and with a ventral keel which is best developed on III. The solenidia on the first five segments of the legs have no perceptible spiral structure.

Tarsus I (Fig. 31) with s_1 at 0.47*pd*, a smooth eupathid at 0.75*pd*, and a heavy, smooth eupathid at 0.87*v*. A smooth normal seta at 0.80*d*. Otherwise with 25 hemipectinate normal setae. Claws as described for II. Tarsus II (Figs. 34, 35) with a spikelike famulus at 0.68*pd*, and a clavate solenidion$_2$ at 0.67*d*, the stalk sometimes showing distinct spiral structure. A long, smooth, normal seta at 0.81*d* and a eupathid at 0.80*pv*, otherwise with 21 hemipectinate normal setae. Claws two in number, the anterior one smoothly curved, scythe shaped, the posterior one with similar taper and thickness, but with a sharp 90 degree flexure between basal and middle thirds. Tarsus III (Fig. 46) with a smooth normal seta at 0.65*d;* otherwise with 14 normal hemipectinate setae. Tarsal claw as on I and II.

TYPE LOCALITY: Tule Lake, Siskiyou County, California (holotype female). Common along alkali-encrusted shore of lake, on mud overgrown with grasses and other plants. Types in author's collection.

REMARKS: This species is widely distributed throughout the western United States, living in marshy situations. It has also been collected at a point about 4 miles north of Tonasket, Okanogan County, Washington, on the borders of small ponds on the Okanogan River. These ponds are permanent, and are usually flooded each year. A second species, *C. ap-*

	tr	bf	tf		pa		ti			ta				
	n	n	s_2	n	s_2	n	s_2	s_4	n	s_1	s_2	e	f	n
I	1	1	1	5	4	5	1	1	4	1	0	2	1	26
II	1	2	1	4	2	4	1	0	4	0	1	1	1	22
III	1	2	1	4	2	4	1	0	4	0	0	0	0	15

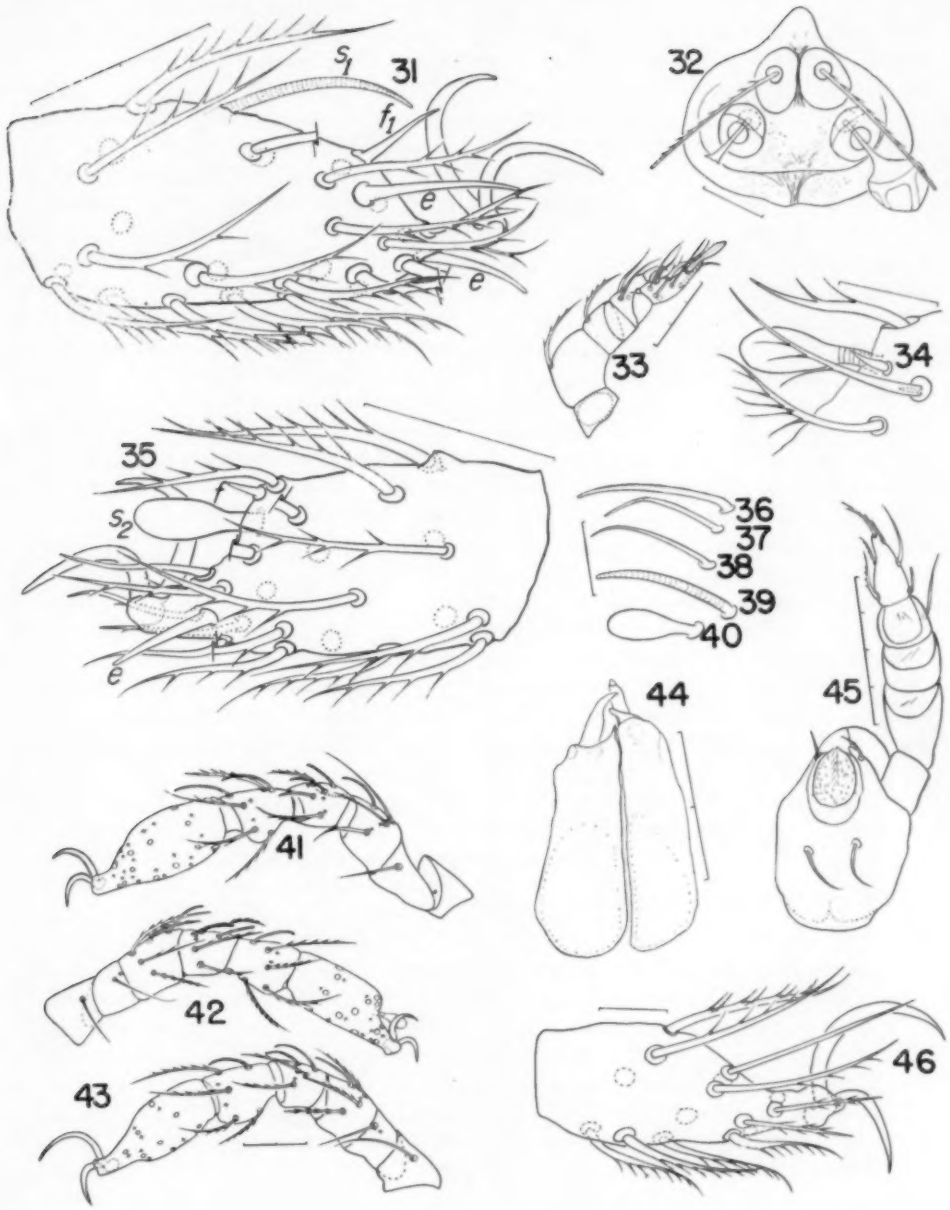
proximatum n. sp. was found at the latter locality. This is very similar to *C. distans* but differs in at least three consistent respects. Because of the high degree of variation found in the Johnstonianidae and the terrestrial Parasitengona in general, it is often difficult to assess the significance of small variations between individuals. However, all individuals of *Centrotrombidium* seen by the writer fall into one of two groups depending upon the degree of separation between the clavate solenidion$_2$ and the famulus on tarsus II (Figs. 6, 49). In both males and females of *C. distans* these are widely separated as described above; whereas in the others the clavate solenidion and famulus are very close together. Moreover, the famulus in *C. distans* is borne on a protruding vesicular base while that of the other form arises from an alveolus which is set at or below the general surface of the cuticle. The second arrangement has been found in both males and females so that sexual differences are not involved. A second difference is in the number of solenidia on the dorsal surface of tibia I. These segments are approximately the same size in the two forms, but in *C. distans* there are approximately 34 to 41 solenidia; whereas in the second form there are only about 20. A third difference, in the form of the scutum, is discussed in the description of *C. approximatum*.

Centrotrombidium approximatum new species

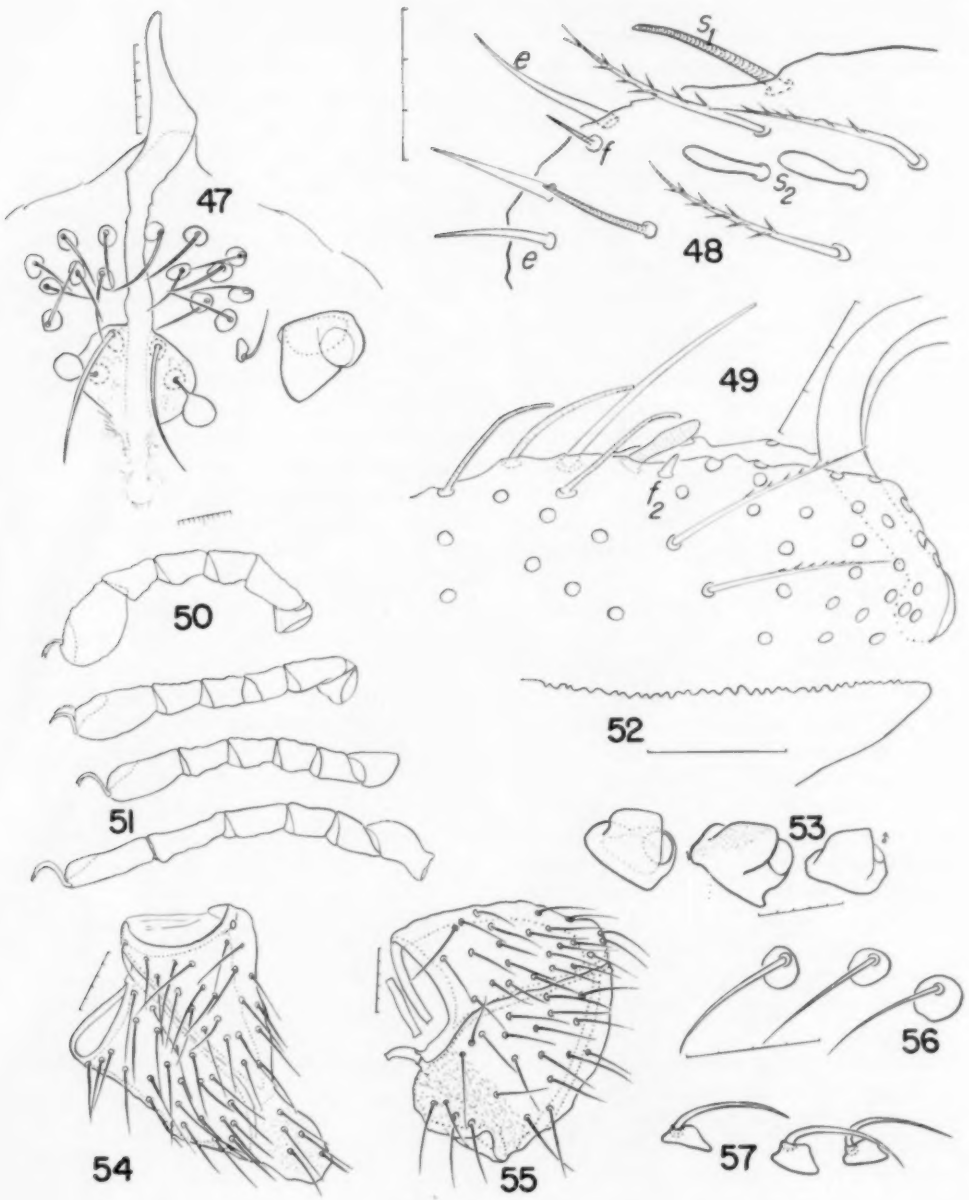
FEMALE: Very similar to *Centrotrombidium distans* new species in size and general appearance. Length 988 to 1092 μ to tip of scutal spine, width 728 to 884 μ, length/width 1.23 to 1.35; average 1050 μ long, 801 μ wide, length/width 1.31 (five ovigerous females). Scutum slightly larger than in *C. distans*, with the portion behind the area sensilligera of nearly uniform width throughout in contrast with the expanded form of this part in *C. distans*. Crista metopica well developed, the portion between the area sensilligera and the scutal spine being somewhat longer generally than in *C. distans*, but this is a variable feature. Posterior sensilla spherical distally, anterior sensilla absent; scutum with only one pair of setae in addition to the sensilla. With 2 to 8 setae between the scutum and each ocular plate (average 4.5 setae, six specimens). Ocular plates appreciably larger than in *C. distans* (Fig. 53) bearing a single cornea laterally and a large lobe medially. The medial lobe is punctate like the rest of the ocular plate, and apparently is never tuberculate as it frequently is in *C. distans*. Dorsal and marginal body setae apparently slightly longer than in *C. distans*, each borne on a separate sclerite, but these sclerites are more nearly hemispherical, and noticeably less elevated than in the preceding species (Fig. 57). Membranous cuticle of dorsum smooth, subcutaneous reticular layer as in *C. distans*.

Coxae I and II with 27 and 26 smooth, slender setae each, pars medialis coxae with 5 setae (one specimen). Coxal ring I incomplete dorsally, supracoxal setae absent; coxal ring II complete. Both I and II with a large articulating process in anterior portion of coxal ring (Fig. 54). Intercoxal area of I and II with 9 to 20 smooth, simple setae, each borne on an individual sclerite; no apodemes behind II. Coxae III and IV with 27 and 25 smooth slender setae respectively in specimen counted, coxal rings complete dorsally; also with a prominent articular process on the anterior half of the coxal ring. Genital and paragenital sclerites as in *C. distans* (Fig. 10), genital sclerites with a single row of 9 to 11 setae, paragenital sclerites with a single to double row of 12 to 17 setae. Three pairs of genital acetabula. Anal sclerites also as in *C. distans*, with 6 to 10 setae on each side.

Base of gnathosoma essentially as in *C. distans* but with a larger number of setae (6 to 10). Velum directed anteriorly, protorostral setae of same form as in *C. distans;* a pair of ventrally directed setae distiventrally on rostrum as in the case of *C. distans*. It appears probable that these are the tritorostral setae, for between these and the protorostrals is a



FIGS. 31–46. *Centrotrombidium distans* n. sp., larva: 31, tarsus I; 32, scutum (sensillum crumpled); 33, palp, posterior; 34, famulus and solenidion$_2$, tarsus II; 35, tarsus II; 36, solenidion$_1$, tibia I; 37, s_3, patella III; 38, s_4, femur III; 39, s_1, tarsus I; 40, s_2, tarsus II; 41, leg I; 42, leg II; 43, leg III; 44, chelicerae, dorsal; 45, gnathosoma, ventral; 46, tarsus III.



FIGS. 47–57. *Centrotrombidium approximatum* n. sp.: 47, propodosoma, male; 48, tarsus I, female, posterior; 49, tarsus II, male, posterior; 50, legs I and II; 51, legs III and IV, female; 52, cheliceral tarsus, female; 53, ocular plates, female to left, male to right; 54, coxae I and II, female; 55, coxae III and IV, female; 56, hysterosomal setae, female, from above; 57, hysterosomal setae, side view.

pair of minute structures like those found in *C. distans* which may represent the vestiges of the deutorostral setae. Including the protorostrals and tritorostrals the rostrum bears 10 to 16 setae. Chelicerae (Fig. 60) of standard form, tarsus heavily sclerotized, appearing smooth at low magnification but with 20 to 30 extremely minute teeth visible at magnifications of 250 x or higher. Trochanter of palp (Fig. 61) with fenestral membrane on anterior aspect, setae absent; femur with about 12 smooth straight slender setae. Two of the normal setae on the femur of the palp appear to occupy a characteristic posterior position, isolated from the remaining 10 setae of the segment. Patella with about 9 setae, tibia with 8 smooth slender setae plus the large clawlike unidentate distal seta, and a shorter spiniform seta near its base. Tarsus of palp with three rather heavy normal setae along dorsal margin (Figs. 58, 59), two heavy eupathids distally, and a single solenidion posteriorly.

MALE: Resembling female in all essential respects noted above except for structure of genital area. Genital sclerites and paragenital sclerites as in female, but with slightly fewer setae in most cases. Penis of rather characteristic form, with three elongate apodemes. Genital acetabula numbering three pairs. Anal sclerites also as in female.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae, m = many).

Basifemur I with about 20 to 25 normal setae. Vestigial setae absent; eupathidia found only on the tarsi. Tarsus I with famulus at 0.89*pd* and with two solenidia$_2$ on posterior aspect (only one in some cases). Tarsus II with s_2 at about 0.64*pd*, and with a spikelike famulus at 0.64 to 0.73*pd*. Eupathidia extending from 0.55*v* to 0.95*d*. Eupathidia of tarsus I extending from 0.49*v* to 0.85*d*. Tarsus I also with numerous s_1 and a number of smaller solenidia intermediate in size and form between s_1 and s_2, and assigned in the table to type s_4. There appears to be fairly complete intergradation between s_4 and s_1 as in the case of *C. distans*.

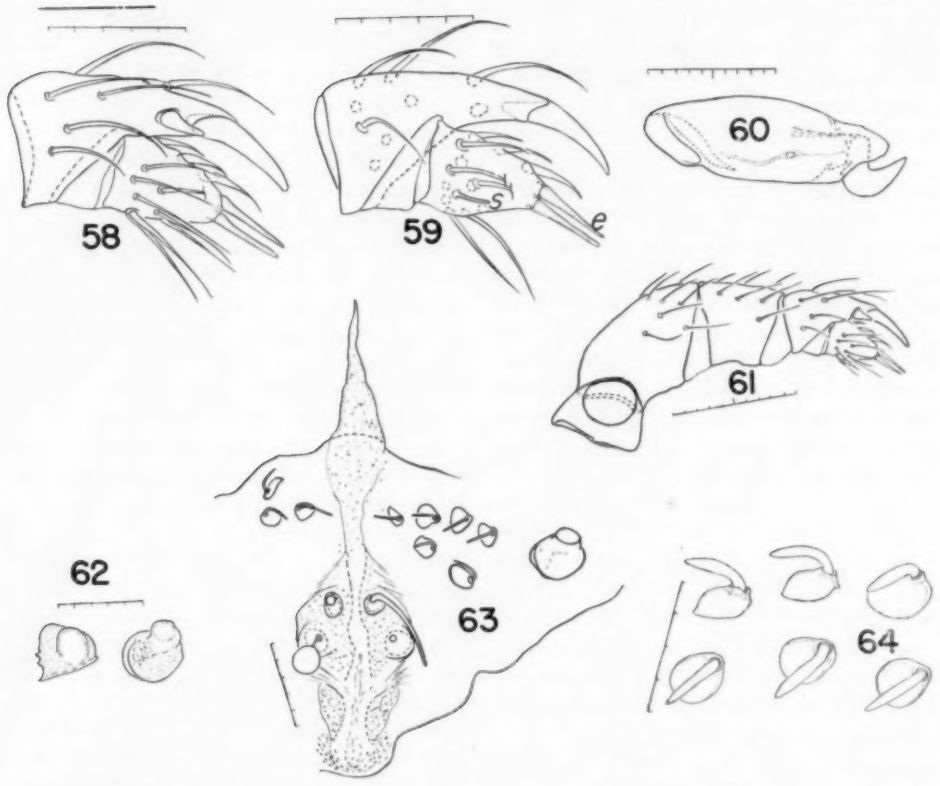
TYPE LOCALITY: About 4 miles north of Tonasket, Okanogan County, Washington, from border of small permanent pond. August 14, 1952. Collected by the writer. This species has not been found elsewhere, and may be a more northerly form, whose principal range extends into British Columbia.

REMARKS: This species is very similar to *Centrotrombidium distans* new species, but differs consistently in the close approximation of s_2 and the famulus of tarsus II (hence the specific name). It also differs in having considerably fewer solenidia on the legs (approximately 125 compared with 200 in *C. distans*). The difference is largely due to the discrepancy in the number of s_2 (about 80 in *C. approximatum*, compared with 160 in *C. distans*); the other solenidial types are present in approximately equal numbers in the two species. Other differences are in the form of the posterior end of the scutum, and the form of the ocular plate as indicated in the foregoing description.

Centrotrombidium badroseta new species

FEMALE: A single specimen of this form was found at the type locality of *C. approximatum*. It is closely related to *C. distans* from which it differs in only very minor respects. Body of same form as *C. distans*, 962 μ long, 650 μ wide, length/width 1.48. Scutum (Fig. 63) essentially as in *C. distans*, except that the setae in front of the sensilla appear to be

	tr	bf	tf	pa		ti		ta					
	n	n	s_2	s_3	s_4	s_3	s_4	s_1	s_2	s_3	s_4	e	f
I	4–5	23	11	31	2–3	7–9	1	11	2,*1*	0	7	m	1
II	4–5	15–16	6	10	1	6	1	11	1	0	0	m	1
III	6	11–13	4	8	2	4	1	0	0	2	3	8	0
IV	12	9–10	4	6	0	4–5	0	0	0	1	1,2	1,0	0



FIGS. 58–61. *Centrotrombidium approximatum* n. sp.: 58, tibia and tarsus of palp, female, anterior; 59, tibia and tarsus of palp, female, posterior; 60, chelicera, female; 61, entire palp, female, anterior.

FIGS. 62–64. *Centrotrombidium hadroseta* n. sp., female: 62, ocular plates, anterior aspect on left, dorsal aspect on right; 63, propodosoma; 64, hysterosomal setae, side and top view.

somewhat shorter. Sensilla with terminal portion spherical, rather abruptly differentiated from stalk as in *C. distans*. Ocular plates (Fig. 62) with a single hyaline cornea plus a large punctate posterior lobe bearing a few tubercles. Dorsal body setae borne on individual sclerites as in other members of the genus, the sclerites in the form of very low cylinders, relatively lower than those of *C. distans;* shaft of setae short, extending only a little beyond the margin of the setigerous sclerite, appreciably thicker than in *C. distans*, and not tapering uniformly as in that species (hence the name). Other details of dorsum and venter essentially as in *C. distans*. Genital sclerites with 7 and 8 setae each, paragenital sclerites with 15 and 16 setae each. Anal sclerites each with 7 setae. In the holotype female, the solenidion of the tarsus of the palp is located somewhat more distally than in the previously described species, and the terminal eupathidia of the tarsus are somewhat longer; however, it is impossible at present to know whether these differences are of real significance.

The material available is not suitable for counts of the setal types. In general the chaetotaxy appears to resemble that of *C. distans* very closely. Tarsus I bears either 2 or 3 clavate solenidia$_2$, with the normal two being located at 0.67 and 0.74*p* in the specimen studied. One of the tarsi I of the holotype has a third s_3 at 0.52 *pd*. Eupathidia of tarsi I extending from 0.34*v* to 0.83*pd*. Famulus elongate, straight, its alveolus at 0.88*pd*. Claw fossa extending from 0.72*d* to end of tarsus. Tarsus II with a clavate s_2 at 0.61*pd* and a spikelike famulus at 0.81*pd*. These positions correspond almost precisely with the positions of the same setae in the holotype of *C. distans*, but the famulus appears to have a normally recessed alveolus, and not a vesicular one as in *C. distans*.

TYPE LOCALITY: About 4 miles north of Tonasket, Washington, on border of a small permanent pond (holotype female). August 14, 1952, collected by the writer. This is also the type locality of *C. approximatum* new species. Type in author's collection.

REMARKS: The type locality of this species is the only point at which more than one species of *Centrotrombidium* has been observed by the writer, all three forms newly described in this paper having been found here. The differences between *C. distans* and *C. hadroseta* cannot be fully evaluated at present because of lack of sufficient specimens of the latter species. However, 50 specimens of both sexes of *C. distans* have been seen by the writer, and there is no indication of convergence in setal type between any of these specimens and the type of *C. hadroseta*. While it is possible that further study will change this, the most probable explanation at present appears to be that we have here two sibling species.

Centrotrombidium misellum
(Berlese) 1918, new combination

This was originally described as *Diplothrombidium misellum* Berl. (*sic*). A translation of Berlese's description is given above.

395. *Diplothrombidium misellum* Berl. n. sp. Dark red, small. Abdomen subquadrate–rounded, very slightly excavated in lateral margin, front truncate, well-armed posteriorly. Crista metopica with a single area sensilligera, anterior and posterior sensilla very close together; anterior sensilla spiniform, moderately swollen, posterior sensilla long, very slender. Body completely clothed with hemispherical papillae, setae short arcuate, directed posteriorly. Legs very short, anterior ones shorter than body, tarsus broad, ovate, little longer than broad (140 μ long, 80 μ broad), tibia three times narrower than the tarsus. Palpi rather large, barely swollen, unguiculate, provided with a stout spine at the base of the main claw three times shorter than the claw. Papilla, (tarsus?) conical, short, apex armed with three spiniform setae, 30 μ long, cuticle of legs, rough, warty, covered with simple short setae. Eggs in hysterosoma of the single specimen which I saw spherical, 140 μ in diameter. Adult 800 μ long, 650 μ wide.

HABITAT: A single specimen collected by Cl. Alph. Dugès, in Mexico (Guanajuato), which Cl. Trouessart kindly sent to me.

The swollen form of the leg tarsi, the presence of a single pair of true sensilla on the scutum, and the description of the tarsus of the palp and its terminal setae leave little doubt that this is not a *Diplothrombium* but more likely a *Centrotrombidium*. The eupathidia at the end of the tarsus of *C. approximatum* are almost exactly 30 μ long, while those of *Diplothrombium micidium* are 62 μ long. No known species of *Diplothrombium* has a palpal tarsus which could be described as "conical," but this term could be applied to *Centrotrombidium*. The length of the body is also much more in keeping with *Centrotrombidium* than with *Diplothrombium*. The species should therefore be transferred to the genus *Centrotrombidium*. If it does not belong in that genus, its position there is at least no more untenable than it was in *Diplothrombium*. The only point in which Berlese's diagnosis was out of character with *Centrotrombidium* is in the form of the sensilla. However, a trend toward more slender sensilla is seen in *C. australasiae*, and it is not inconceivable that there might be some species in which these are not swollen.

Johnstoniana George 1909

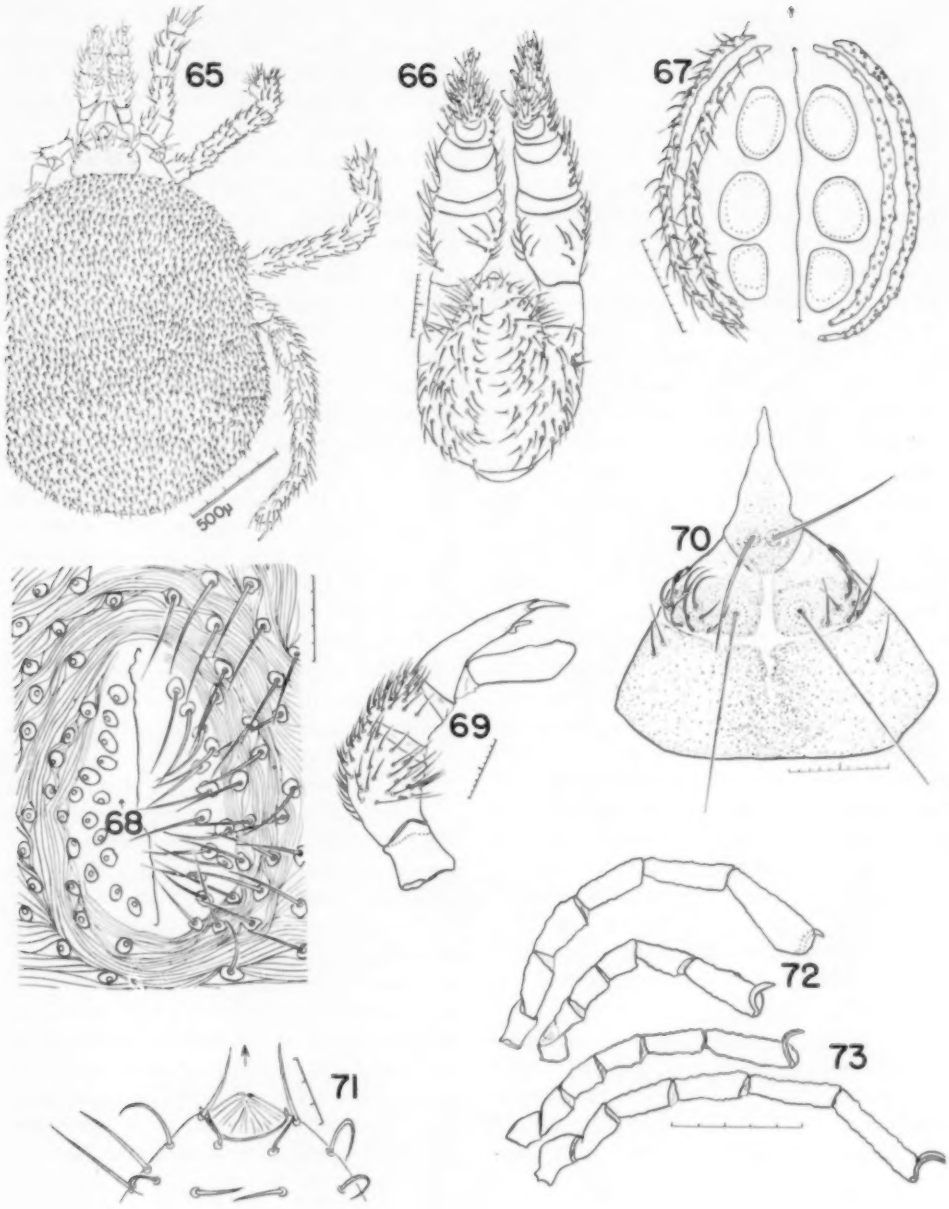
ADULT: Large mites, idiosoma 1,000 to 3,000 μ in length, scutum a broad, roughly pentagonal plate with a prominent anterior spine, two pairs of slender sensilla and a fairly well-developed crista metopica. Lateral to the posterior sensilla is a group of several smooth setae, and in the posterior half of the plate usually one or two somewhat isolated setae. Ocular plates protruding, bicorneate; propodosoma lateral to scutum devoid of setae. Dorsal hysterosomal setae simple, smooth, borne on individual sclerites which may be elevated or not. Coxae I without supracoxal setae; intercoxal area with numerous smooth setae borne on individual sclerites; pars medialis coxae present. Genital and paragenital sclerites well developed, pregenital tubercle absent, three pairs of genital acetabula. Anal sclerites absent in *J. latiscuta* new species. Only two pairs of rostral setae, the deutorostrals apparently absent. Trochanter of palp not fenestrated, considerably longer anteriorly than posteriorly. Palpal tarsus with a single solenidion on posterior surface, and a number of prominent eupathidia. Palpal tibia with a simple terminal spiniform seta, and a single subterminal spiniform seta. Solenidial types s_1 and s_2 distinct, but s_1 and s_4 difficult to differentiate; s_2 relatively short, stout, marked with four longitudinal ridges. Eupathidia present on all segments of all legs including and beyond the telofemur. Vestigial setae present on patella I and II, but absent on tibia I and II.

LARVA: Scutum bearing two pairs of sensilla plus two pairs of other setae, all simple, smooth. Crista metopica present; anterior end of scutum drawn out into a frontal spine. Supracoxal setae absent. Urpore present. Tip of rostrum with only two pairs of setae, the deutorostrals apparently absent. Tarsus of palp with a single solenidion on posterior surface; typical eupathids absent, although the terminal setae of the tarsus are probably modified eupathids. Femora I to III incompletely divided dorsally in *J. latiscuta*. Patella I and II each with a vestigial seta dorsally, but tibia lacking vestigial setae. Dorsal eupathid of tarsus I with a basal companion seta. Tarsi of all legs with two unequal claws.

REMARKS: The structure of the adult scutum as delineated by Berlese and reproduced by various authors is incorrect. Because of the very sharp downward flexure of the scutum between the posterior and anterior sensilla, the configuration of the scutum in undissected specimens is noticeably different from that seen in dissected specimens (Figs. 70, 86). Little is known of the biology of our one North American species except that it is apparently a cold stenothermal species found along mountain streams. *J. errans* (Johnston) 1852 has larvae which are parasitic upon Tipulidiae. Cooreman (1952, p. 109) reported only one case in which he found this ordinarily rare species in great numbers at one point along a small stream in Belgium. This rarity is apparently characteristic of the species described here, for the writer has seen only one female and a larva of *J. latiscuta*. Cooreman reported the capture of 44 females, but no males, which points up the fact that males have not yet been reported for this genus.

Johnstoniana latiscuta new species

FEMALE: Body of ovigerous female about 1816 μ long to tip of scutum, 1330 μ wide, length/width 1.37; color in life a brilliant brick red (Fig. 65). Scutum (Figs. 70, 86) with two pairs of slender, smooth sensilla; plate divided into two portions, a broad extensive posterior portion bearing the posterior sensilla and lateral and posterior to these six to eight setae on either side. The anterior portion is set off by a sharp declivity and bears only the anterior pair of sensilla, in front of which is a rounded knob produced ventrally into a sharp spine. Crista metopica well developed in anterior half of scutum, feebly developed to absent in posterior half. Ocular plates protruding, prominently bicorneate;



FIGS. 65–73. *Johnstoniana latiscuta* n. sp., female: 65, dorsum; 66, gnathosoma; 67, genital area; 68, anal area; 69, palp, anterior; 70, scutum; 71, tip of rostrum, ventral; 72, legs I and II; 73, legs III and IV.

cuticle between ocular plates and scutum devoid of setae. Dorsal and marginal body setae (Fig. 84) borne on prominently elevated setigerous sclerites uniformly distributed over the distinctly striated membranous cuticle.

Coxa I with about 60 simple, smooth setae, plus 6 to 9 simple, smooth setae on the pars medialis coxae which appears to be a discrete medial expansion of I (Fig. 82). Supracoxal seta I absent. Coxa II with 45 setae. Membranous area between coxae I and II of right and left sides with 79 smooth setae, borne on individual sclerites. Behind coxa II a wide (75 μ) band of striated cuticle devoid of setae. Marginal setae especially dense between II and III, borne on sclerites which are markedly convex but not cylindrical. In the single specimen available, no trace was found of the characteristic organ just anterior to coxa III in *Lassenia lasseni*. Coxa III with 41 setae; IV with 55 (Fig. 75). No apodemes visible between II and III. Genital opening (Fig. 67) large, with three pairs of genital acetabula; genital sclerites very narrow, crescentic, bearing 34 to 36 slender, smooth setae, mostly in a single to double row. Paragenital sclerites with 52 to 55 similar setae in a single to triple row. The setae on both sets of sclerites are fairly uniformly spaced except at the ends where there are fewer setae than at levels in between. Ventral body setae borne on hemispherical sclerites, membranous cuticle marked with regular but not parallel striae. Anus (Fig. 68) lacking well-defined sclerites, surrounded by cuticle only faintly differentiated from that of rest of venter.

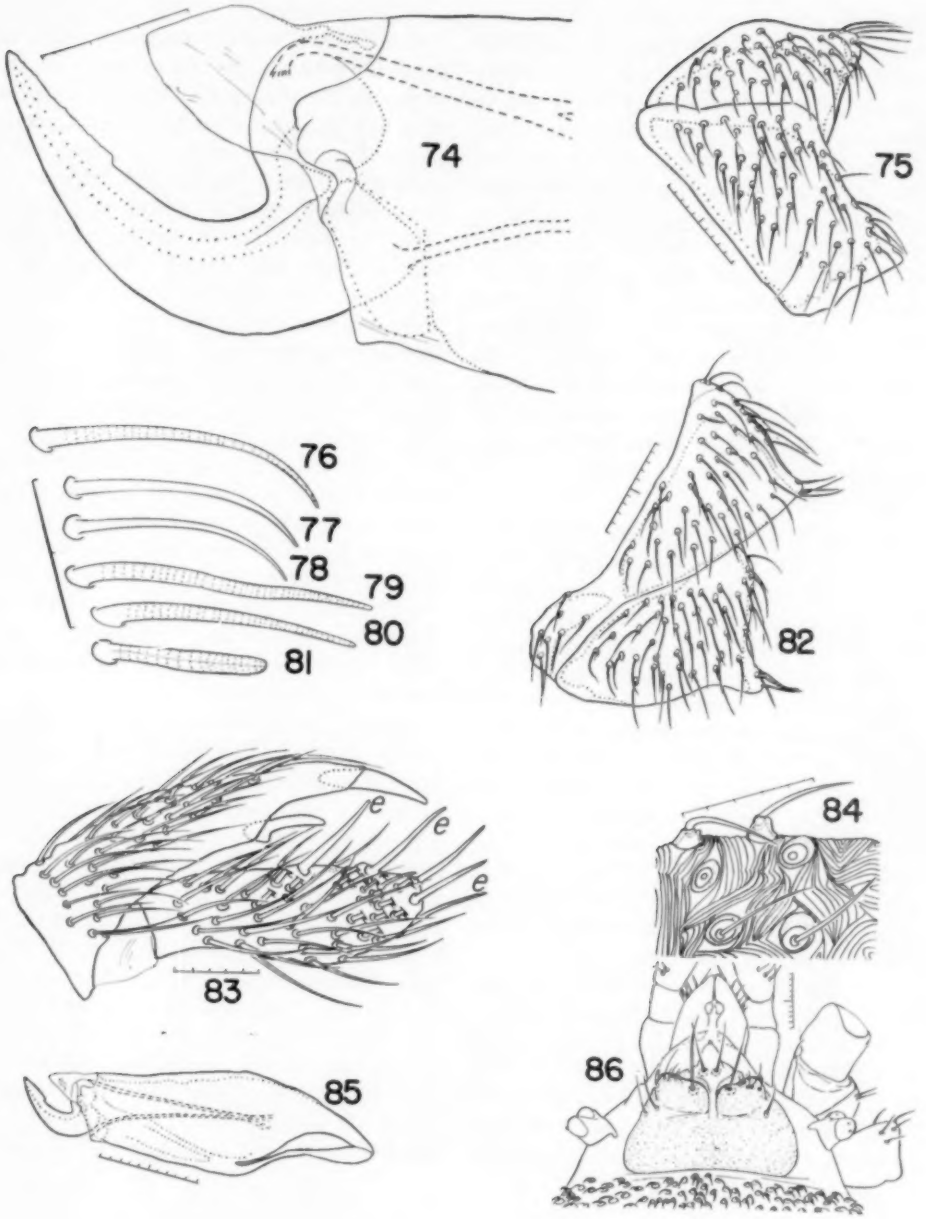
Velum circular to oval in outline, numerous fine filaments converging from a well-defined marginal rim (Fig. 71). Protorostral and tritorostral (? see larva) setae present and well developed; ventral surface of gnathosoma otherwise with 80 to 100 smooth simple setae on either side of the bare mid-ventral line (Fig. 66). Rostrum very short, blunt, extending scarcely beyond the end of the trochanter of the palp.

Chelicerae (Figs. 74, 85) with distal half of tarsal claw slightly raised, knifelike, appearing minutely serrate under oil immersion. Trochanter of palp (Figs. 66, 69) devoid of setae and also without any trace of the fenestration which characterizes the palpal trochanter of the other genera; trochanter considerably longer anteriorly than posteriorly. Terminal segments of palp covered with many long, slender, smooth setae. Tibia with a unidentate terminal seta and a stout subterminal seta at 0.67*v*, the latter bearing a basal tooth or spur. A few of the dorsal setae of the tibia, at least in the distal half, are slightly heavier than the other setae, but are not otherwise different from them. Palpal tarsus with a large eupathid at 0.57*d*, and five other eupathids at 0.73*a*, 0.81*d*, 0.94*v*, 0.95*p*, and 0.97*d*. A single solenidion at 0.84*p* (Fig. 83).

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae, m = many).

All segments of all legs beyond the basifemur with one or more eupathidia, recognizable by their reverse curvature. Vestigial setae fairly long and slender, about half the length of the surrounding solenidia$_3$, confined to patella I and II, absent from tibiae. Tibiae with numerous s$_3$ (Figs. 77, 78) I and II with only about one seta each which could be assigned to type four. Tarsus I with three s$_1$ at 0.73*d* to 0.76*pd*, plus four others at 0.27 to 0.33*d* which may possibly belong in this category. Solenidial types s$_1$ and s$_4$ are convergent in form and difficult to differentiate. Tarsus I

	tr	bf	tf		pa			ti				ta					
	n	n	s$_3$	e	s$_2$	e	v	s$_2$	s$_4$	e	v	s$_1$	s$_2$	s$_3$	s$_4$	e	f
I	18	m	2	1	63	3	1	m	1	4	0	3–7	7	0	m	m	1
II	33	m	1	1	20	3	1	20	1	2	0	4	1	0	10±	20±	1
III	30	m	1	1	26	2	0	16	0	3	0	0	0	0	7±	3,4	0
IV	40	m	1	1	35	2	0	28	0	2	0	0	0	5±	0?	2	0



FIGS. 74–86. *Johnstoniana latiscuta* n. sp., female: 74, end of chelicera; 75, coxae III and IV; 76, solenidion$_4$, tibia I; 77, s_3, patella I; 78, s_3, femur I; 79, s_1, tarsus I; 80, s_1, tarsus II; 81, s_2, tarsus I; 82, coxae I and II; 83, tibia and tarsus of palp, posterior; 84, hysterosomal setae; 85, chelicera; 86, propodosoma.

also with seven s_2 at 0.72*pd* to 0.92*pd*, these being short, slightly clavate, and longitudinally ribbed; s_3 absent, s_4 numerous. Many eupathidia extending from 0.36*v* to 0.20*d*. Famulus$_1$ at 0.70*d* very similar to the eupathidia in form, but somewhat shorter and broader at the base. Tarsus II with four solenidia$_1$, at 0.23, 0.38, 0.54 and 0.57*d*; a single s_2 at 0.60*d*, at the base of the claw fossa. Precise number of s_4 not determinable with material available; eupathidia numbering about 20. Famulus$_2$ at 0.57*d* very small, short, peglike, easily overlooked. Tarsus III with about seven solenidia intermediate to types s_2 and s_4, but more closely resembling the latter. Tarsus IV with about five solenidia, which appear to belong to type s_2.

MALE: Unknown.

LARVA: Only one specimen of the larva was taken and this was in such poor condition that neither measurements nor counts of the numerous body setae could be made. Scutum (Fig. 90) with two pairs of smooth, slender sensilla and two pairs of finely barbed setae (oil immersion). Anterior end of scutum with a knoblike projection bearing at its tip a smaller conical projection. Crista well developed; extending to level of anterior sensilla. Cuticle finely and densely punctate. Dorsal and marginal body setae slender, tapering to a very fine point, and smooth; each seta borne on an individual sclerite which is rather feebly delimited from the surrounding unstriated membranous cuticle.

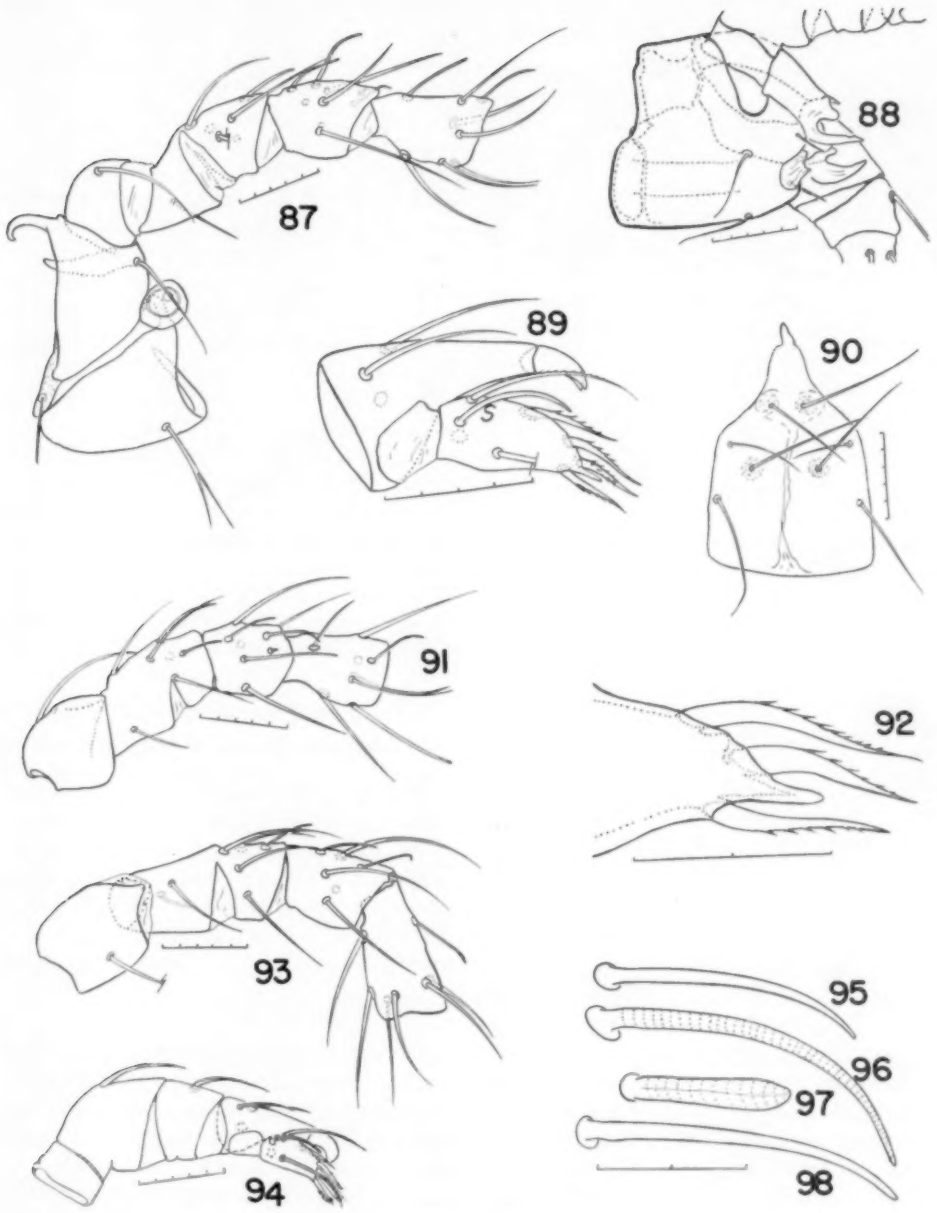
Coxa I with two setae, including the one on the rather well-developed pars medialis coxae, II and III each with a single seta, that on II bifurcate on both right and left sides of the single specimen available (Figs. 87, 101). Urpore well developed. Supracoxal setae on I apparently absent but material not very satisfactory for study.

Gnathosoma bearing only two pairs of setae, the protorostrals and probably the tritorostrals, the deutorostrals apparently absent (Fig. 88). Supracoxal setae absent. Rostrum short, blunt; velum simple. Chelicerae short, compact, tarsus scythe-shaped with one or two small teeth near the tip. Palpal trochanter (Fig. 94) without setae, femur and patella with a single seta dorsally which appears smooth at low magnifications, but at high magnifications can be seen to have three or four very minute barbs. Tibia with three normal setae in basal half, plus the bidentate terminal clawlike seta. Tarsus with a solenidion very near the base, three long, slender, normal setae also in basal half plus four heavy pectinate setae in distal half. Typical eupathids are absent, although the four hemipectinate setae in the distal half of the segment evidently represent the eupathids of the adult.

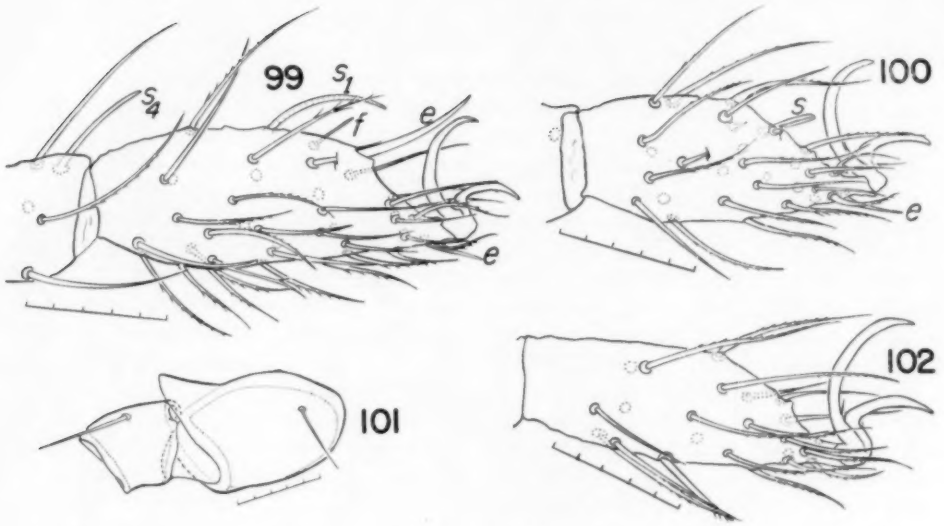
Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae).

Femora I to III (Figs. 87, 91, 93) incompletely divided; with a well-developed synarthrodial membrane ventrally but the cuticle in the dorsal part of the segment continues with no trace of interruption from the basifemoral to the telofemoral portion. Although there is no true articulation dorsally as found between other segments of the leg, there is undoubtedly considerable flexibility at this joint. Telofemoral portion of femur, patella and tibia of all legs with one or more solenidia$_3$ dorsally. Patella I and II each with a vestigial seta dorsally, but tibiae lacking vestigial setae. Tarsus I (Fig. 99) with annulate dorsal solenidion$_1$ at 0.45*d*, a straight, elongate, smooth famulus at 0.56*pd*, eupathid and

	tr	bf	tf		pa				ti				ta					
	n	n	s_2	n	s_2	s_4	v	n	s_3	s_4	v	n	s_1	s_2	e	f	c	n
I	1	1	1	5	4	0?	1	4	0	2	0	6,7	1	0	2	1	1	37
II	1	2	1	4	2	0?	1	4	1	1	0	6	0	1	1	1	0	28
III	1	2	1	4	2	0	0	4	1	1	0	6	0	0	0	0	0	23



FIGS. 87–98. *Johnstoniana latiscuta* n. sp., larva: 87, leg I, and coxae I and II; 88, gnathosoma, ventrolateral; 89, tibia and tarsus of palp, posterior; 90, scutum; 91, leg II, trochanter to tibia; 92, tip of palpal tarsus; 93, leg III, trochanter to tibia; 94, palp, posterior; 95, solenidion$_2$, patella II; 96, s_1, tarsus I; 97, s_2, tarsus II; 98, s_4, tibia I.



FIGS. 99–102. *Johnstoniana latiscuta* n. sp., larva: 99, tarsus I, anterior; 100, tarsus II, anterior; 101, coxa III; 102, tarsus III.

companion seta at 0.70*d*, and a shorter one at 0.88*pv*. Tarsus II with short, spikelike famulus$_2$ at 0.50*pd*, a clavate, carinate solenidion$_2$ at 0.59*pd*, and a rather straight eupathid at 0.84*pv*. Tarsus III with no specialized setae. Anterior and posterior claws on all legs with a sharp spine at the basal third of the concave side; anterior claw gently curved throughout length, posterior claw sharply bent just beyond the spine.

TYPE LOCALITY: At origin of King's Creek, Lassen Volcanic Park, California, August 6, 1955 (holotype female). Collected by the writer. Type in author's collection.

REMARKS: The correlation of the female with the larva described above must be regarded as tentative, although it is almost certain that they belong to the same species. The two specimens were found within about a foot of each other under rocks on the edge of the stream. There is no question about their generic identity.

It is not possible to compare this species with other presently described forms because of the inadequacies of the description of the latter. However, it is probable that detailed comparisons would prove it distinct.

Johnstoniana vitzthumi Womersley 1939

While it is apparent from the original figures and description that this species belongs in the Johnstonianidae, it is impossible to compare it reliably with other members of the family, or even to ascertain that it is truly a *Johnstoniana*. The description was based on a single specimen collected in South Australia.

Diplothrombium Berlese 1910

ADULT: Fairly large mites, idiosoma usually between 1,000 and 2,000 μ long, color in life dark reddish-brown. Scutum elongate, narrow, bearing an anterior spine, and well-differentiated anterior and posterior areae sensilligerae (Figs. 110, 160). Two pairs of smooth, slender sensilla, and usually two pairs of shorter normal setae in the posterior area sensilligera. Dorsum of propodosoma with a few to many setae borne on individual

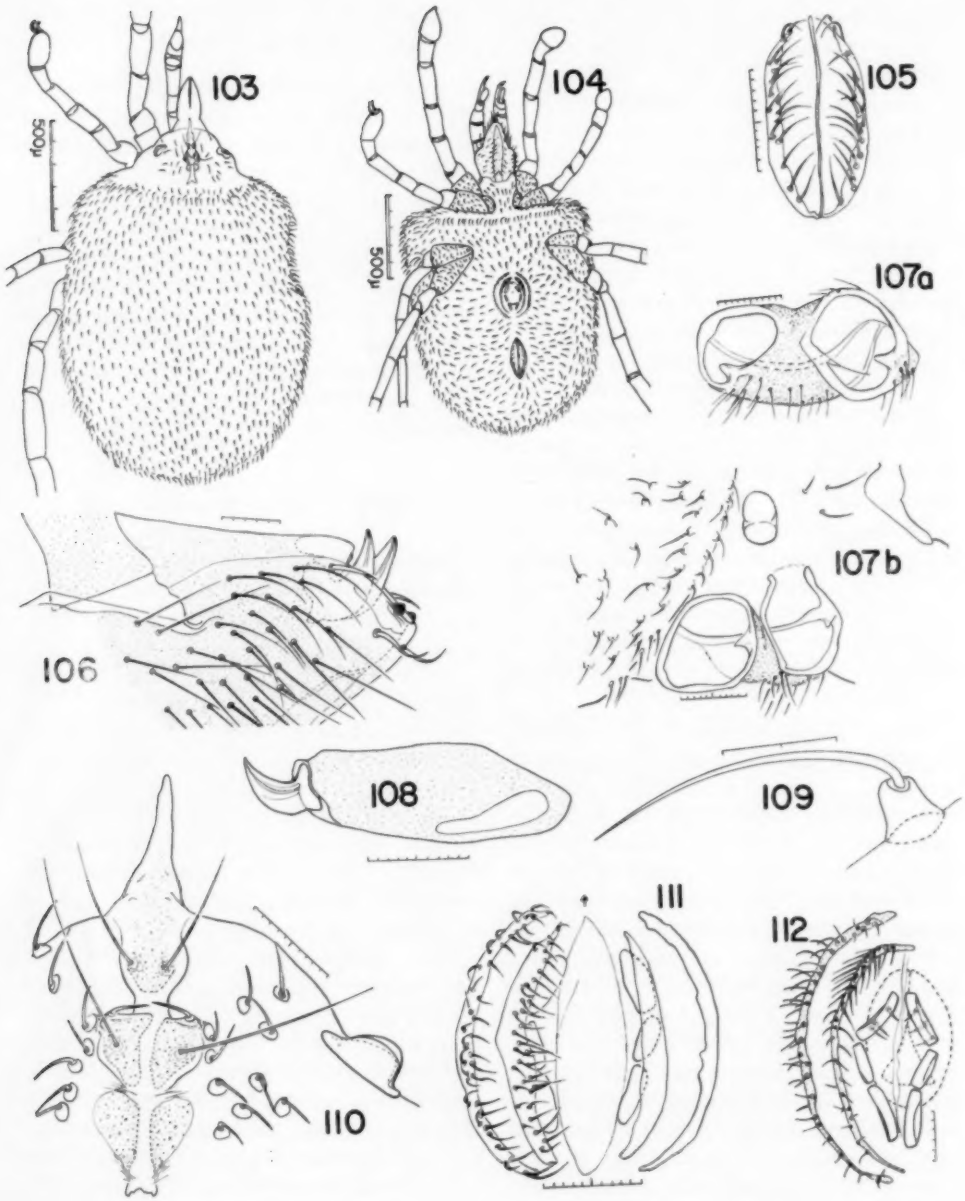
sclerites between the scutum and ocular plates. Dorsal hysterosomal setae smooth, borne on individual elevated sclerites. Ocular plates protruding moderately, bicorneate. Coxa I lacking supracoxal setae; coxal ring of II complete dorsally, that of coxa I membranous dorsally. Intercoxal area with numerous smooth, slender setae, each borne on individual sclerites; pars medialis coxae well developed. Genital and paragenital sclerites well developed, three pairs of genital acetabula. Anal sclerites crescentic, bearing a number of smooth setae. Rostrum apparently only with the protorostral and tritorostral setae, plus other setae behind these; deutorostrals absent. Trochanter of palp fenestrated anteriorly; tibia with one large terminal and one subterminal clawlike seta. Tarsus of palp with a single solenidion posteriorly, and a number of eupathidia in the distal half. Legs with solenidia of four fairly distinct types, s_2 being especially distinctive, clavate. Eupathidia present on all segments of all legs including and beyond the telofemur. Vestigial setae completely absent.

LARVA: Scutum with two pairs of sensilla, the anterior pair very small; otherwise with two pairs of normal setae. Crista metopica well developed, anterior portion of scutum produced into a process of variable form. Ocular plates bicorneate. Dorsal and ventral surfaces of body covered with numerous setigerous sclerites. Coxal setae numbering 2–1–1 in known species. Intercoxal area with a single pair of setae between III; urpore present. Gnathosoma bearing only two pairs of setae, probably the protorostrals and tritorostrals. Supracoxal setae absent on both the gnathosoma and on leg I. Podocephalic canals well developed. Anterior wall of trochanter of palp fenestrated. Palpal tarsus with a single solenidion near basal end; eupathidiform setae absent, although some of the terminal setae must be modified eupathidia. Solenidia$_3$ present on telofemur of legs I to III; s_1 elongate, somewhat decumbent, s_2 stout, clavate. Tarsus II with only one eupathid. All legs with six free segments beyond the coxa, and two subequal tarsal claws.

REMARKS: The larvae described here are the first described for the genus as a whole, and, of course, *D. monoense* is the first species in which the larva and adult are both known. Species of this genus are found in very moist situations and are cryptic in habits, avoiding direct sunlight as much as possible. Although experimental evidence is not yet available, they are evidently incapable of tolerating high temperatures for any length of time. The larvae are of the self-detaching type; they have been found parasitizing the pupae of aquatic beetles under wet rocks.

Diplothrombium monoense n. sp.

FEMALE: Idiosoma (Fig. 103) highly variable in size, 1,638 to 1,820 μ long, 1,092 to 1,326 μ wide, length/width 1.43 to 1.52; average 1,706 by 1,180 μ, length/width 1.45 (five ovigerous specimens). Scutum (Fig. 110) with two pairs of completely smooth sensilla, and between them a pair of stiff setae appearing hemipectinate under high magnification. Posterolateral to these is a second pair of setae contiguous with, but not fully enclosed by the scutum. Anterior end of scutum produced into a long blunt spine. Crista metopica well developed, extending from posterior margin of anterior area sensilligera to posterior end of scutum. Behind the posterior area sensilligera is a lateral expansion on either side of the crista metopica, bearing a number of coarse punctations. Ocular plates small, scarcely larger than the two corneae found on each side, strongly convex but not stalked, setae absent. Dorsal and marginal body setae (Fig. 109) smooth, slender, tapering, typically with a sharp basal flexure. Alveoli borne on individual sclerites which are sharply elevated above the general surface of the cuticle in the form of a truncate cone. Propodosomal cuticle between the scutum and ocular plates and lateral to the ocular plates generally with



FIGS. 103–112. *Diplothrombium monoense* n. sp.: 103, dorsum, female; 104, venter, male; 105, anus, male; 106, gnathosoma, male, lateral; 107a, coxae III and IV, male, lateral; 107b, coxae I and II, male, lateral; 108, chelicera, female; 109, hysterosomal seta, female, side view; 110, propodosoma, female; 111, genital opening, female; 112, genital opening, male.

fewer than ten setae. Cuticle seemingly devoid of striae or other markings except for the underlying reticular layer.

Coxae I and II (Fig. 122) with about 50 and 60 setae respectively, plus 7 to 10 setae on the pars medialis. All setae smooth. No supracoxal setae; coxal ring I open dorsally, II closed dorsally (Fig. 107b). Coxae III and IV with 70 to 75 setae each, coxal ring of each complete dorsally (Fig. 107a). Cuticle of all coxae faintly punctate. Intercoxal area between I and II with 65 to 70 smooth slender setae, each borne on a small sclerite; a narrow band of cuticle behind coxae I and II devoid of setae. No sclerotized plates in the membranous area between coxae II and III. Ventral body setae like those on dorsum, except that the sclerites are not so prominently raised. Genital sclerites (Fig. 111) bearing 35 to 45 smooth slender setae; paragenital sclerites narrower than genital sclerites but bearing 43 to 50 setae of the same form as those on the genital sclerites (three specimens). Genital acetabula well developed, the second pair the smallest. Anal sclerites (Fig. 105) quite variable, with from 11 to 19 setae arranged in a single to double row; setae similar to those on genital sclerites.

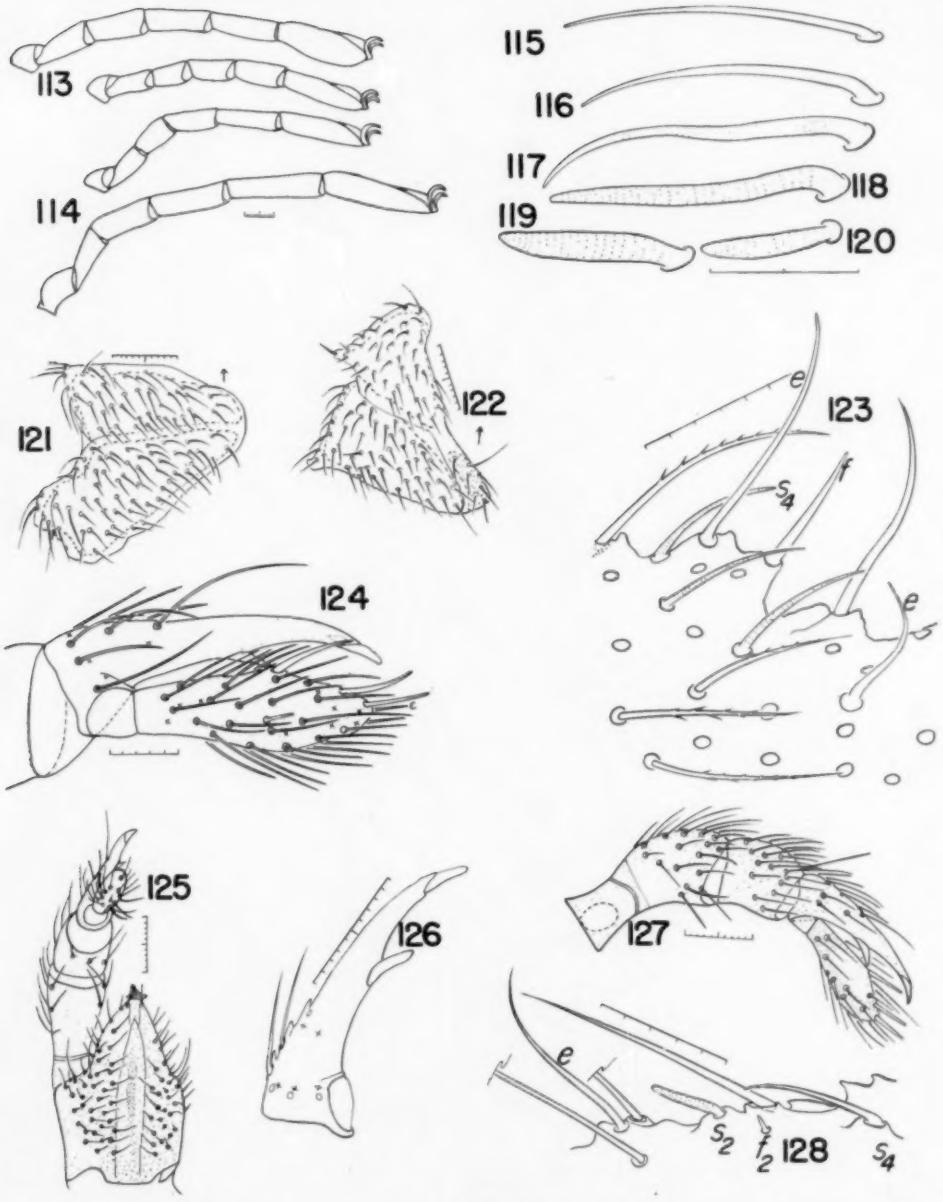
Base of gnathosoma and rostrum bearing about 45 setae on each side, supracoxal setae absent. Rostrum relatively short and broad; tip of rostrum (Fig. 106) with two pairs of specialized setae, presumably the protorostrals and tritorostrals. Velum small, circular, and oriented in an anterior direction (Fig. 125). Chelicerae as shown in Figure 108. Trochanter of palp (Fig. 127) devoid of setae; medial wall fenestrated. Tibia with a heavy spiniform seta at 0.58*v* and a second one at the end of the segment. A series of three very sharp spines dorsally, in basal third of tibia (Fig. 126). Tarsus with a large eupathid borne on a prominent tubercle at 0.61*d* and a group of two large and two small eupathids near the tip of the segment (Fig. 124). A single solenidion at 0.57*p*. Normal setae of palp smooth and tapering.

Trochanters I and II with about 8 setae dorsally, three with about 10 setae dorsally, and four with 20 to 25 setae, all these setae smooth to faintly hemipectinate. All basifemora lacking specialized setae, normal setae on dorsal portions of segment smooth to faintly hemipectinate, those on ventral half of segment usually very fine and smooth.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae, m = many).

Vestigial setae absent from all legs. Tarsus I with famulus elongate, erect, its alveolus located on a prominent tubercle at 0.31*pd* (Fig. 123). Solenidion$_1$ actually smaller than the corresponding seta on tarsus I of the larva, inserted at 0.52*d* at the origin of the claw fossa. A group of five thick, stout s_2 extending from 0.57 to 0.80*p*. These are generally slightly smaller than the corresponding setae on tarsus II but are the same general form and are internally annulate. Eupathidia very numerous, extending from 0.26*v* to 0.13*d*, or in other words around nearly the entire periphery of the tarsus I. Basal portion of tarsus I from about 0.30*v* to 0.52*d*, extremely rough, provided with sharp, truncate tubercles. These tubercles bear the alveoli of a number of types of setae including the famulus, eupathidia, solenidia$_4$, and bihemipectinate normal setae. The normal setae on all segments of the legs are smooth or very nearly so, with the exception of those of tarsus I. Tarsus II with a clavate s_2 at 0.49 to 0.50*d*, and a spikelike

	tr	bf	tf		pa			ti			ta					
	n	n	s_2	e	s_2	s_4	e	s_2	s_4	e	s_1	s_2	s_3	s_4	e	f
I	7–9	m	16	3	60	2	2	55	2	2	1	5	0	m	m	1
II	7	m	10	3	22	3	3	10	5	3	0	1	0	5	4	1
III	9–11	m	10	3	30	1	2	11	5	3	0	0	0	2	8	0
IV	20–23	m	6	2	30	2	3	13	4	4	0	0	0	4	8	0



FIGS. 113–128. *Diplothrombium monoense* n. sp.: 113, legs I and II, female; 114, legs III and IV; 115, solenidion$_3$, telofemur I; 116, s_3, tibia I; 117, s_1, tarsus I; 118, s_1, tarsus I; 119, s_2, tarsus II; 120, s_2, tarsus I; 121, coxae III and IV, female (115–120 all female); 122, coxae I and II, female; 123, famulus and other setae of tarsus I, female; 124, tibia and tarsus of palp, female, posterior; 125, gnathosoma, female; 126, tibia of palp, female; 127, entire palp, female; 128, tarsus II, female.

famulus at 0.45 to 0.52*d*, these setae of the same form as the corresponding ones in the larva. Tarsus II apparently lacking s_1, the remaining solenidia being s_4 (Fig. 128). All tarsi with a distinct claw fossa on dorsal surface, and most segments of legs with exception of trochanter and basifemur bearing many angular dorsal protuberances which give the legs a rough appearance. Two claws on all tarsi, the claws flattened and with a median ventral carina.

MALE: Similar to female in most respects observed, with the principal exception of the genital opening (Fig. 112). Genital opening guarded by two pairs of sclerites as in female, but these have many more setae. Anterior 0.4 of each genital sclerite with 45 to 50 close-packed smooth, long, slender setae; remaining 0.6 with only about 20. Paragenital sclerites each with about 40 to 45 smooth setae, 6 or 8 of which are appreciably heavier than the others. Penis not triangular, but small and tubular. Three pairs of prominent genital acetubula. Anal sclerites with 14 to 17 smooth, slender setae.

LARVA: Body 343 to 389 μ long, 233 to 279 μ wide, length/width = 1.36–1.57; average 369 by 253 μ, length/width = 1.46 (five specimens). Scutum (Fig. 129) with a knob-like protuberance anteriorly, and a pair of very small sensilla inserted near the base of this. The knob bears a short, blunt point ventrally, but this is not visible in dorsal view. These setae, while not especially sensillar in form, are forerunners of the anterior sensilla in the adult. Setae at anterolateral and posterolateral angles bihemipectinate. Posterior sensilla very long, slender, smooth. Crista metopica well developed in anterior one-half (sometimes in posterior one-third also) of scutum. A patch of moderately coarse pores (250 x) near posterior margin; surface otherwise marked with numerous fine punctae and an irregular reticulum medially behind the sensilla. These pores and reticulae are also evident in the adult (Fig. 110). Corneae two on each side, borne on a common ocular plate. Dorsal setae 36 in number, borne in five transverse rows (8, 8, 8, 8, 4; Fig. 131). Each seta faintly hemipectinate (250 x), borne on an individual sclerite, the central portion of which is moderately elevated (Fig. 130). Membranous cuticle with parallel striae, which are sometimes indistinct.

Coxa I (Fig. 144) with two bifurcate setae; medial portion of coxa caudiform, indistinct. Supracoxal seta absent. Coxa II with one bipectinate seta laterally; coxa III with one smooth seta. Intercoxal area (Fig. 138) with only one pair of setae between coxae III; postcoxal area with 36 to 38 hemipectinate ventral and marginal setae on each side, all borne on individual sclerites. Presumptive anal opening distinct.

Gnathosoma with a single pair of bifurcate setae ventrally, presumably the tritorostrals. Rostrum very short; protorostral setae smooth. Velum small. Podocephalic canals well developed. Supracoxal setae absent. Cheliceral base very thick; digitus fixus membranous (Fig. 134); digitus mobilis smooth, except for one tooth. The ventral margin of the digitus mobilis in the specimen drawn was bent, but this may not be normal. Palpi five-segmented (Fig. 133). Trochanter lacking setae, femur and patella each with one long, smooth dorsal seta. Tibia with three smooth setae and a hooked terminal spiniform seta which usually appears unidentate in lateral view, but bifid in ventral view. Palpal tarsus (Figs. 132, 136) with solenidion basally on lateral surface. Tip of tarsus drawn out into a flat, sharp spine; a faintly pectinate seta arising dorsally at the base of the spine gives the tarsus a bifid appearance. Otherwise with six setae, all but two of which are faintly hemipectinate. No typical eupathidiform setae present, although the heavy pectinate setae are quite certainly the forerunners of these.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, n = normal setae).

Trochanters I to III each with one large ventrally curved seta. Basifemora all distinctly

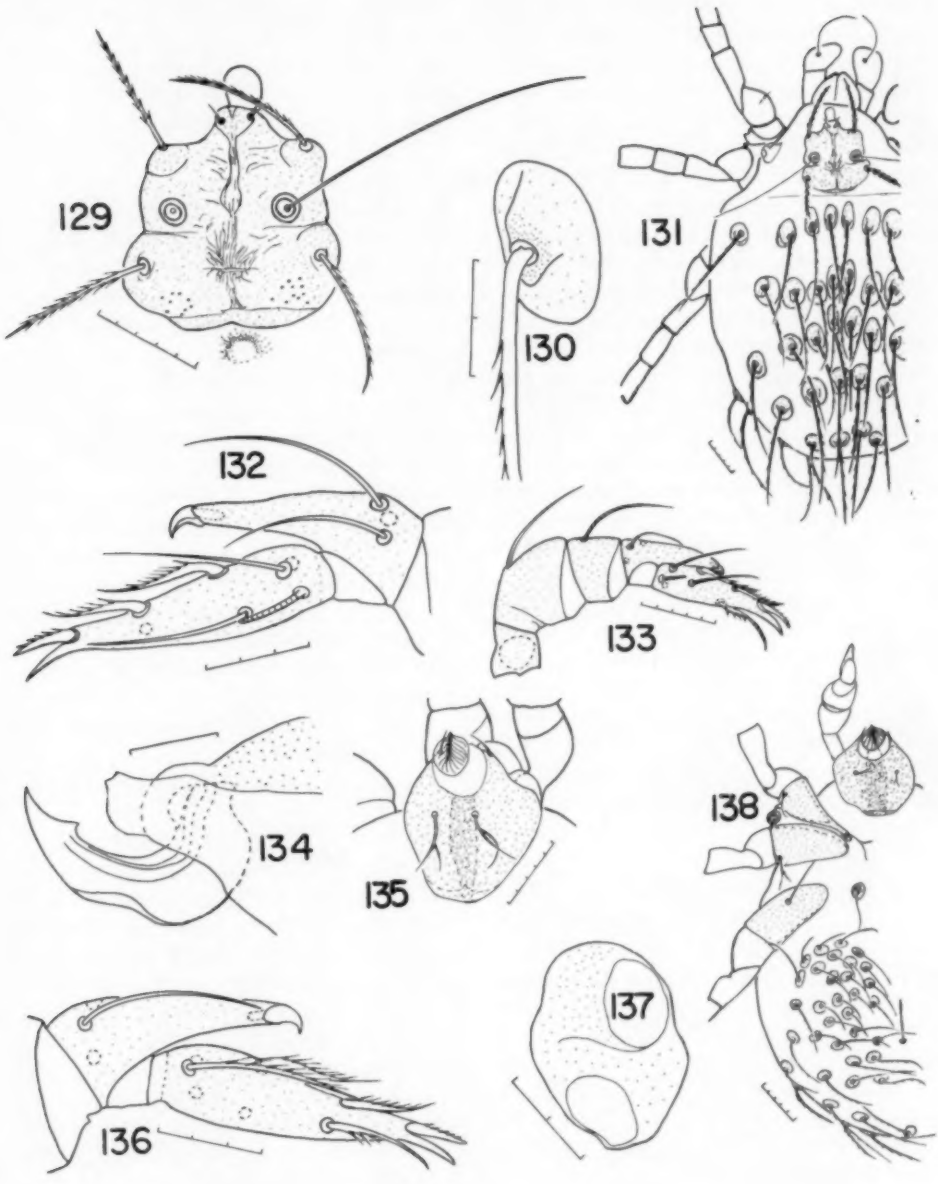
	tr	bf	tf		pa		ti			ta				
	n	n	s_3	n	s_3	n	s_3	s_4	n	s_1	s_2	e	f	n
I	1	1	2	5	15	4	1	1	6	1	0	2	1	34
II	1	2	1	4	2	4	0	2	6	0	1	1	1	27
III	1	2	1	4	2	4	0	1	6	0	0	0	0	20

separated from telofemora; I with a large ventral seta, but no dorsal seta, II and III each with a large hemipectinate dorsal and a small, smooth ventral seta. Telofemur I with two dorsal solenidia$_3$ (Figs. 139–141), II and III with one each; otherwise with 5, 4, and 4 smooth to faintly pectinate setae respectively. Vestigial setae and companion setae absent from all segments of all legs. Tarsus I (Fig. 143) with a long famulus at 0.42*pd* and a long solenidion$_1$ at 0.44*d*, the latter lacking annular structure, but with internal surface granular (oil immersion). Solenidion, when seen in dorsal view, not straight, but very gently bisinuate. A long eupathid at 0.66*d*, but no companion seta, and a shorter one at 0.93*v*. A pair of long, slender setae at 0.87 and 0.89*ad* and *pd*, and another at 0.88*av*. Otherwise with 31 bihemipectinate setae in specimen drawn. Tarsus II (Fig. 145) with famulus at 0.45–0.52, a club-shaped solenidion$_2$ at 0.55*d*, three slender, smooth setae at 0.80*d*, 0.83*d*, and 0.83*v*, and a eupathid at 0.89*pv*. Otherwise with 24 bihemipectinate normal setae in specimen drawn. Tarsus III (Fig. 142) with five slender, smooth setae at 0.79*d* to 0.86*v*. Otherwise with 15 bihemipectinate normal setae on tarsus drawn. Two claws on all tarsi, the anterior one larger than the posterior one; all claws smooth.

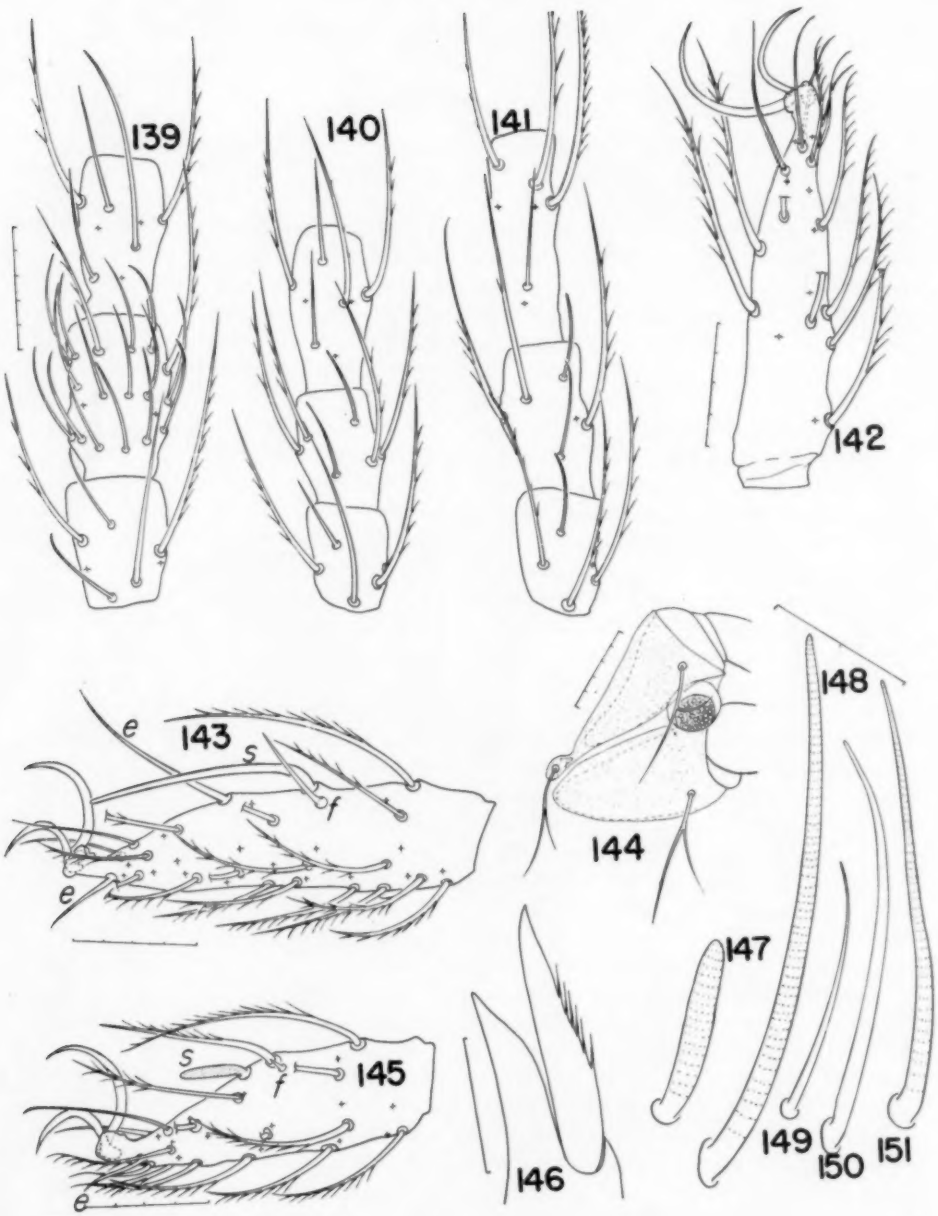
TYPE LOCALITY: Mono Lake, Mono County, California, 0.9 miles north of Leevining (holotype female). Type in author's collection.

REMARKS: These mites were first found on and under rocks, lying in and near a small tricklet of alkaline water running into the lake, June 1, 1952. The habitat could be termed semiaquatic. The bottom of one rock was covered with scores of pink eggs laid singly and several other rocks were also observed with smaller numbers of eggs but always in association with these adults (June 1, 1952). Eight larvae were found attached to the pupa of an aquatic beetle found under a stone. The larvae were definitely attached to the host and appeared to be feeding, but when submerged in alcohol the larvae immediately detached themselves from the host. The feeding habits of the adult are unknown at present. The same spot was revisited July 1, 1954. A few adults were found at this time, but no eggs, indicating that the reproductive season terminated sometime during the month of June. The same picture was observed when the spot was again revisited August 9, 1955 —although adults and nymphs were fairly common, no eggs or larvae whatever were found.

While found at a site in which very high summer temperatures are registered in exposed places, *Diplothrombium monoense* was never found out in the open where it would be subject to these high temperatures. Also it was never found in situations where there was not considerable moisture, and the majority were found under rocks in which the surface of the ground was actually wet. A few individuals were running about over the surface of very wet ground covered with a dense growth of small plants. Under such circumstances they always appeared restless, especially when their cover was removed so as to expose them to the direct rays of the sun. A species of *Microtrombidium* was also very common at this locality but was frequently found running about over the surface of the dry sand along the shore of the lake, even in the heat of the day. Their movements were generally rapid, but at least they did tolerate the exposure to heat and sun for short periods of time. This species of *Diplothrombium* would appear to be considerably less tolerant of heat and dryness than species of *Microtrombidium*. Fur-



FIGS. 129–138. *Diplothrombium monoense* n. sp., larva: 129, scutum; 130, dorsal seta; 131, dorsum; 132, tibia and tarsus of palp, posterior; 133, entire palp, posterior; 134, end of chelicera; 135, gnathosoma, ventral; 136, tibia and tarsus of palp, anterior; 137, ocular plate; 138, venter.



FIGS. 139–151. *Diplothrombium monoense* n. sp., larva: 139, telofemur to tibia I; 140, telofemur to tibia II; 141, telofemur to tibia III; 142, tarsus III; 143, tarsus I, posterior; 144, coxae I and II; 145, tarsus II, posterior; 146, tip of tarsus; 147, solenidion$_8$, tarsus II; 148, s_1, tarsus I; 149, s_2, femur II; 150, s_4, tibia I; 151, s_4, tibia I.

ther evidence of the narrow temperature tolerance of *D. monoense* was obtained through an unfortunate mishap. A number of adults being brought back to Riverside for rearing studies were killed during the eight-hour transit of the Mojave Desert, despite precautions taken to insulate them from the heat. The same was true of the living specimens of *Lassenia lasseni*—none survived the trip across the desert. At the same time a species of *Microtrombidium* collected at an elevation of 8,000 feet on the slopes of Mt. Lassen did survive, laid eggs, and these eggs eventually hatched. A species of Erythraeidae also survived the exposure to high temperature which was lethal to the two species of Johnstonianidae. The rather low heat tolerance of these species undoubtedly is important in determining their distribution, both geographically and locally.

The correlation between larva and adult was established on the basis of their coexistence at the type locality. More than 90 adults or nymphs and 50 larvae have been collected there, and there is apparently only one species involved.

Diplothrombium micidium new species

FEMALE: Body (Fig. 152) 936 μ to tip of scutal spine, 546 μ wide, length/width 1.48 (one ovigerous female). Scutum (Fig. 160) produced into a stout conical spine anteriorly. Crista metopica well developed, extending from posterior end of scutum to base of spine. Two pairs of sensilla present, the posterior pair borne on the widest portion of the scutum; sensilla completely smooth. Just in front of the posterior sensilla are two pairs of smooth setae, and just lateral to the sensilla a third pair of setae which lie either in the very margin of the scutum or possibly in some cases just outside. The rather broad plate found behind the posterior area sensilligera in *Diplothrombium monoense* is also found in this species but it is small and easily overlooked at low magnification. Ocular plates very small, bearing two protruding corneae; devoid of setae. Dorsal propodosomal cuticle containing about 20 setae on each side between the ocular plate and the scutum; each of these setae is borne on a small sclerite. Dorsal hysterosomal setae (Fig. 167) also borne on individual sclerites, the shaft sharply deflexed at the origin of the seta from the alveolus. Membranous cuticle of dorsum smooth, subcuticular reticulum present but not very prominent. Coxae I and II (Fig. 154) each with about 30 or 31 smooth simple setae, pars medialis coxae with three to four setae each borne in an oval area within the pars. Outside of these oval areas the pars medialis is distinctly reticular in appearance. Supracoxal setae absent on I. Intercoxal area with about 60 setae borne on individual sclerites in the specimen studied (not all shown in the figure), these setae smooth and simple. Two to three narrow refractile chitinous rods in the membranous cuticle behind coxa II; a band of membranous cuticle behind coxa II devoid of setae. Coxae III and IV (Fig. 165) each with about 25 to 30 setae. Genital sclerites (Fig. 164) with 10 and 12 setae each in a single row; paragenital sclerites with 19 and 22 setae each in a single to double row. Three pairs of genital acetabula present. Anal sclerites narrow, crescentic, bearing 9 smooth setae each in the specimen studied (Fig. 158). Ventral setae of hysterosoma all borne on individual sclerites as on dorsum.

Rostrum (Fig. 154) with telorostral and deutorostral setae well developed; remainder of rostrum and base of gnathosoma with 30 setae on each side of the mid-line; mid-ventral portion of gnathosoma devoid of setae. Velum small, anteriorly directed, with numerous converging filaments. Base of chelicera (Fig. 166) compact, densely and minutely punctate; dorsal membrane blunt, tarsus stout, curved, dorsal margin appearing smooth at low magnifications but with a very large number of minute teeth at magnifications above 250 x. Palpi (Fig. 153) with trochanter fenestrated on anterior surface, femur with 20

to 25 setae, patella with about 20 setae. Tibia of palp (Fig. 159) with a few sharp spines along the dorsal margin, 10 simple, smooth setae, plus the terminal clawlike seta and the heavy subterminal seta on the anterior aspect. Tarsus of palp with a solenidion at 0.50*p*, a eupathid at 0.64*d* and four additional eupathids at or near the end of the segment, plus 27 smooth setae. On the right palp of the specimen drawn there was a sharp spine at 0.79*d*, just anterior to the dorsal eupathid; on the left palp no such spine was found in this position, but one was found at 0.8*v*. Chaetotaxy of legs essentially as described for male.

MALE: Body 1,014–1,066 μ long, 520–598 μ wide, length/width 1.78–1.95 (average of 3 specimens 1,040 by 554 μ, average length/width, 1.88). Resembling female in all essential respects except structure of genital area. Genital sclerites (Fig. 155) with 16 to 18 setae in a single to double row, paragenital sclerites with 23–26 setae, also in a single to double row; an internal circlet of about 7 pairs of setae. Genital acetabula numbering three pairs. Anal sclerites as described for female.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, n = normal setae, m = many).

All legs with telofemur to tarsus very rough in appearance (Figs. 162, 163). Solenidia exceptionally well defined, with no intergradation between types; s_3 slender, with no internal structure, s_4 bacilliform with usually distinct internal structure, somewhat variable in length. Solenidia$_1$ and s_2 are not unlike s_3 in general appearance, but differ principally in length and moreover occupy characteristic positions on the tarsi. Solenidia$_4$ absent from all but tarsus of leg I, but present on telofemur to tarsus of legs II to IV. Vestigial setae absent from all legs. Tarsus I with famulus at 0.65*d*, this seta resembling a eupathid but somewhat shorter. Solenidion$_1$ at 0.80*d*, and three s_2 at 0.63, 0.76, and 0.87*p* (Fig. 161). Tarsus II (Fig. 156) with spikelike famulus at 0.59*d*, s_2 at 0.60*d*, and a group of five s_4 at 0.18*d* to 0.49*p*. Tarsus II with only two eupathidia, one at 0.54*pd*, the other at about 0.95*pv*. Eupathidia present on all segments of all legs beyond the basifemur, but few in number, rarely exceeding three except on tarsus I. Eupathidia of tarsus I extending from 0.35*v* to 0.39*d*. All tarsi with two slightly subequal claws and a rather small claw fossa.

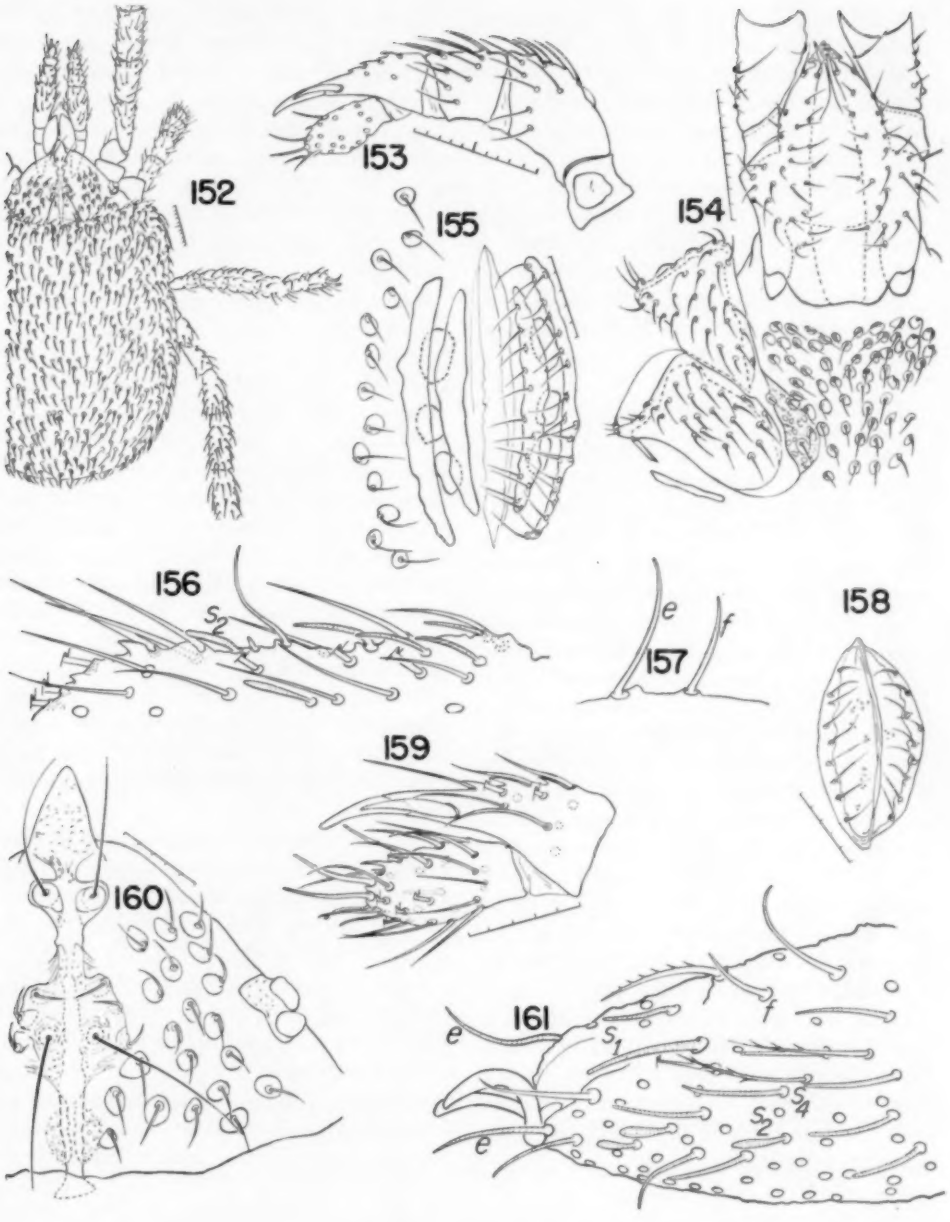
LARVA: Unknown.

TYPE LOCALITY: East fork of Hat Creek, above Hat Lake, at an elevation of about 7,250 ft., Mount Lassen, California (holotype male), under rocks and sticks along the stream in a cascade meadow. August 7, 1955, collected by the writer. Type in author's collection.

The writer wishes to express his appreciation to the National Park Service for their cooperation in these studies. As a general rule, most forms which can be collected within National Park boundaries can also be collected outside with nearly equal facility. However, three species of great interest in the present work (*D. micidium*, *Johnstoniana latisscuta*, and *Lassenia lasseni*) have been found only within the limits of Lassen Volcanic Park, despite intensive collecting at a large number of points in the Pacific coast states.

REMARKS: This species can be readily differentiated from *D. monoense* n. sp. by several characteristics. It is much smaller, the length being about 1,040 μ compared with 1,630 to 1,820 μ for *D. monoense*. There are about 20 dorsal propodosomal setae outside of the scutum, compared with fewer than 10 in most

	tr	bf	tf			pa			ti			ta					
	n	n	s_3	s_4	e	s_3	s_4	e	s_3	s_4	e	s_1	s_2	s_3	s_4	e	f
I	6	m	19	0	1	53	0	2	58	0	3	1	3	0	41	m	1
II	4,5	m	4	1	1	10	2	1	8	3	2	0	1	0	5	2	1
III	6	m	7	1	1	13	4	2	10	3	3	0	0	0	5	2	0
IV	14	m	7	3	1	17	6	3	16	5	3	0	0	0	5,6	2,3	0



FIGS. 152–161. *Diplothrombium micidium* n. sp.: 152, dorsum, female; 153, palp, anterior; 154, gnathosoma, coxae I and II, intercoxal area, female; 155, genital area, female; 156, tarsus II showing setal types, female; 157, famulus and nearby eupathid, male; 158, anus, female; 159, tibia and tarsus of palp, female, anterior; 160, propodosoma, female; 161, tarsus I, female, posterior.

specimens of *D. monoense*. The genital and paragenital sclerites of the female have considerably fewer setae than in the comparison species; also the genital sclerites of the male have 16 to 18 uniformly spaced setae, while in *D. monoense* there is a dense concentration of setae in the anterior 0.4 of the plate. Famulus$_1$ is at 0.65*d* while in *D. monoense* it is at 0.29–0.32*d*. The solenidion$_1$ of tarsus I is at 0.80*d* compared with 0.52*d* for *D. monoense*. Other differences can be found in the descriptions of the two species, or by comparison of specimens.

Diplothrombium cascadense new species

LARVA: Idiosoma (Fig. 168) 261 to 315 μ long, 189 to 225 μ wide, length/width = 1.38–1.44; average of eight specimens 288 μ by 207 μ, length/width = 1.41. Scutum (Fig. 174) with two pairs of sensilla, the posterior ones long, smooth, the anterior ones very short; otherwise with four faintly pectinate setae. A knoblike projection at the anterior end of the scutum, acuminate in normal specimens, but the point usually directed ventrally and ordinarily visible only in lateral view. This point is much better developed than in *D. monoense*. A distinct transverse line crosses the scutum behind the posterior sensilla. Crista metopica distinct. Corneae two on each side, borne on a feebly developed and protruding ocular plate. Dorsal and marginal setae about 30 in number, each borne on a platelet, shaft smooth, or with a very few fine barbs. Membranous cuticle striate.

Coxal and intercoxal chaetotaxy (Fig. 169) as in *D. monoense*. No supracoxal seta on I. Postcoxal area with only about 20 smooth setae on each side, each borne on a separate plate. Anal anlage well developed, but without sclerites.

Base of gnathosoma as described for *D. monoense;* supracoxal setae absent. Palpal trochanter fenestrated anteriorly, lacking setae (Fig. 179). Femur, patella and tibia with one, one and three slender setae respectively, tibia with large, clawlike terminal seta bifid. Palpal tarsus essentially identical with that of *D. monoense*, but smaller. All setae hemipectinate (Fig. 176). Podocephalic canals well developed.

Chaetotaxy of legs as shown in accompanying table (s = solenidia, e = eupathidia, f = famulus, n = normal setae).

Patella I with only 8 solenidia$_2$ dorsally, compared with the 15 in *D. monoense*. Tarsus I (Fig. 178) with large, procumbent solenidion$_1$ at 0.35*d*, eupathidia at 0.59*d*, and 0.89*v*, famulus displaced far anteriorly to 0.65 (the famulus in *D. monoense* is at the same level as the solenidion). Dorsal eupathid without companion seta. A group of three smooth, slender setae at 0.76, 0.80 and 0.84, as in *D. monoense;* otherwise with 29 bihemipectinate normal setae in specimen drawn. Tarsus II (Fig. 175) with short, spikelike famulus at 0.44, a solenidion at 0.47, and a eupathid at 0.86*v*. A pair of smooth, slender setae at 0.77 and 0.80; otherwise with 21 bihemipectinate normal setae.

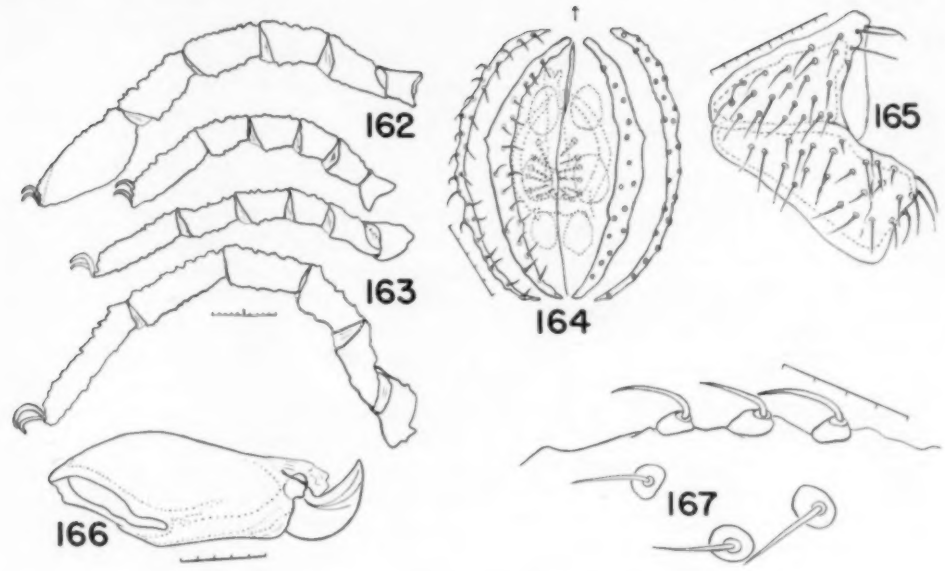
Tarsus III (Fig. 177) with a group of five smooth, slender setae lying between 0.73*d* and 0.84*v;* otherwise with 11 bihemipectinate setae. All tarsi with two smooth, unequal, scythe-shaped claws.

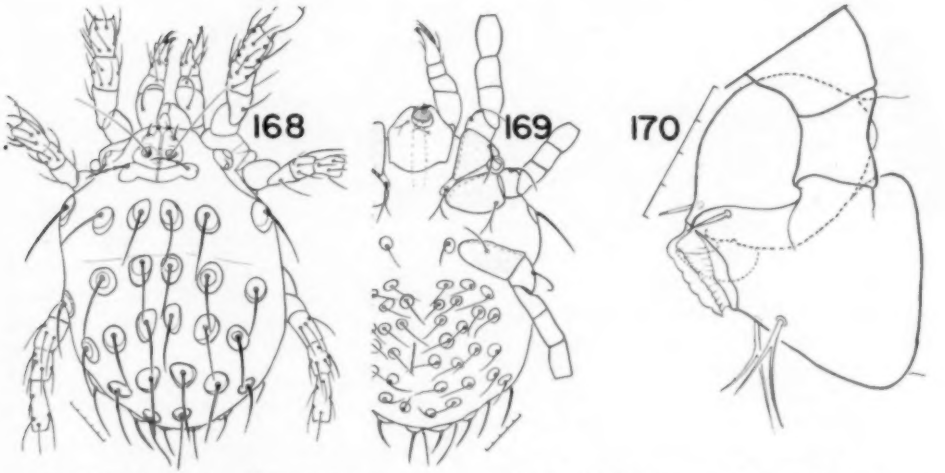
TYPE LOCALITY: Salt Creek Falls, Lane Co., Oregon. Grass and flowers (holotype larva). July 7, 1952. Collected by the writer. Type in author's collection.

REMARKS: The larva of this species differs from that of *D. monoense* in a number of significant respects. It is smaller, ranging in

CHAETOTAXY OF LEGS

	tr	bf	cf		pa		ti			ta				
	n	n	s_2	n	s_3	n	s_3	s_4	n	s_1	s_2	e	f	n
I	1	1	2	5	8	4	1	1	6	1	0	2	1	32
II	1	2	1	4	2	4	1	1	6	0	1	1	1	23
III	1	2	1	4	2	4	1	0	6	0	0	0	0	16

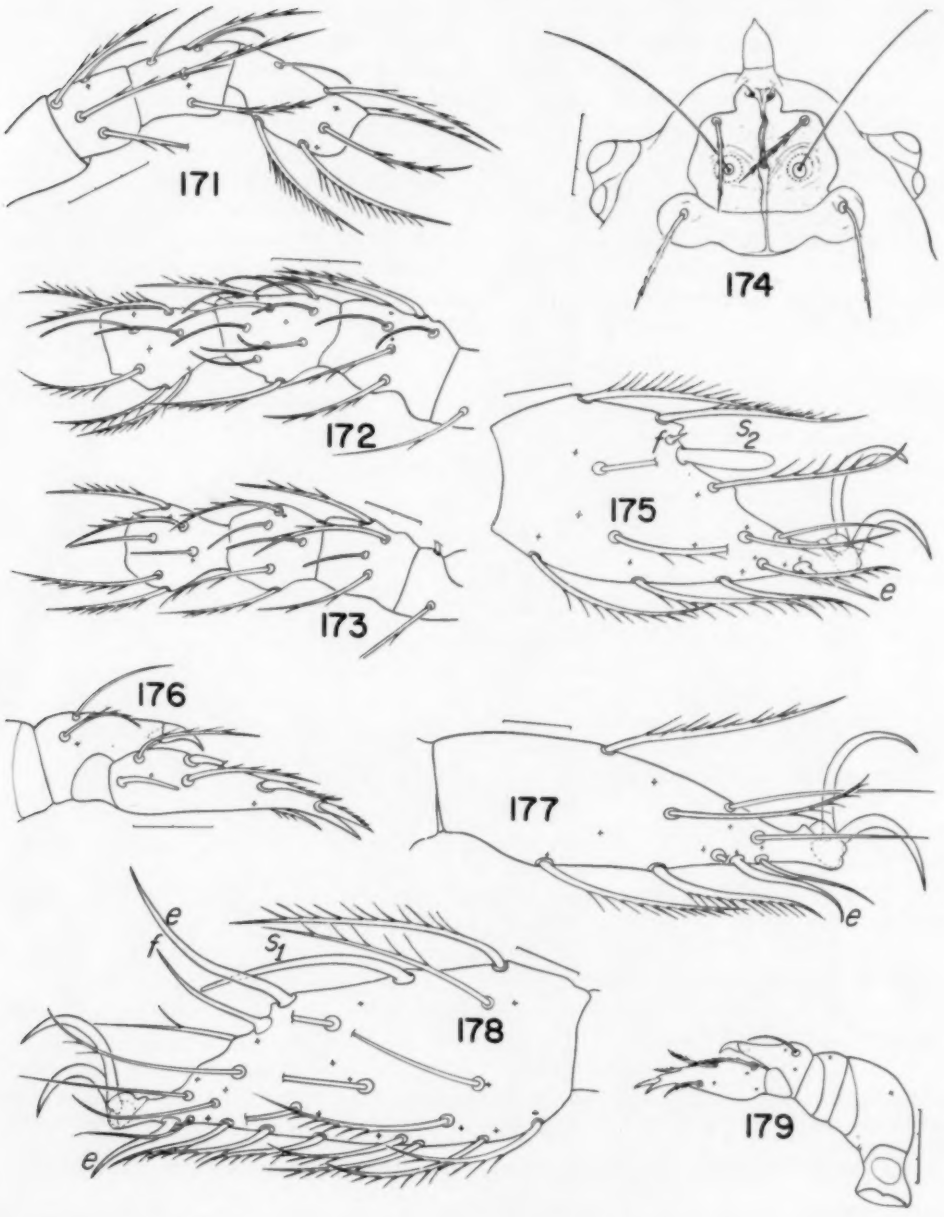




FIGS. 162–167. *Diplothrombium micidium* n. sp.: 162, legs I and II, female; 163, legs III and IV, female; 164, genital area, male; 165, coxae III and IV, female; 166, chelicera, female; 167, hysterosomal setae, female, side and top views.

FIGS. 168–170. *Diplothrombium cascadense* n. sp., larva: 168, dorsum; 169, venter; 170, gnathosoma, lateral view.

length from 261 to 315 μ (*D. m.*: 343 to 389 μ), the dorsal and ventral body setae behind the scutum and coxae number only about 50 (*D. m.*: 72–74 setae here), patella I has only 8 s_3 dorsally (*D. m.*: about 15 s_3 here), and the famulus of tarsus I is at 0.65, while the solenidion is at 0.35 (*D. m.*: famulus$_1$ and s_1 both at about 0.43). Other differences can be



FIGS. 171–179. *Diplothrombium cascadense* n. sp., larva: 171, leg III, telofemur to tibia; 172, leg I, telofemur to tibia; 173, leg II, telofemur to tibia; 174, propodosoma; 175, tarsus II, posterior; 176, tibia and tarsus of palp, posterior; 177, tarsus III, posterior (the smooth seta at 0.74*v* is a normal seta); 178, tarsus I, posterior; 179, entire palp, anterior.

found in the descriptions of the two forms.

No adult of this species was found, despite extensive collections made at the type locality.

Diplothrombium longipalpe Berlese 1887

There is little in the original description of this species which can be relied upon to distinguish critically between this form and the two species described here by the writer. The basal prominence of tarsus I appears to be significantly closer to the base of the segment than in *D. monoense*, but a similar prominence is found in approximately the same position in *D. micidium*. It is probable however that direct comparison of *D. micidium* and *D. longipalpe* would reveal reliable specific differences. Berlese regarded the form named just below as a variety of *D. longipalpe*, but it is likely that if the differences Berlese noted were real that there are two distinct species. A complete bibliography of the species was given by Thor and Willmann (1947, p. 223).

Diplothrombium septentrionale
Berlese 1912, new combination

This form was considered a variety of *D. longipalpe*, but it is almost certainly a distinct species. Again, the information available on this species in the literature is totally inadequate to make any critical comparisons with the two new forms described in the present paper.

Diplothrombium misellum Berlese 1918

Berlese provided no figure of this species, but judging from his description (a single area sensilligera, anterior setae spiniform) this is not a *Diplothrombium* but probably a *Centrotrombidium*. Hence, it is provisionally placed in that genus, *q.v.*

LASSENIINAE new subfamily

DIAGNOSIS: Adults with anterior sensilla greatly reduced or of markedly different form from posterior sensilla. Pregenital tubercle present. Supracoxal setae present on coxa I and gnathosoma in both larva and adult. Larvae with anal sclerites. Deutorostral setae present; terminal seta of palp eupathidiform. Tarsi each with three claws.

REMARKS: To each of the above statements should be added "in known forms." The group will have to be redefined as it becomes better known.

Lassenia new genus

ADULTS: Rather large mites, the known species between 1,000 and 1,700 μ in length, dark brown to brownish red. Scutum large, expanded, several times wider than the width of the crista metopica. Posterior sensilla elongate, slender; anterior sensilla variable in form, resembling the rest of the setae on the scutum so that they are sometimes not readily discernible. Ocular plates bicorneate, protruding, but not stalked. Dorsal setae of hysterosoma simple, smooth, stiff, rodlike in the known species, all of same type. Pars medialis of coxa I either present or absent. Coxal rings I and II both membranous dorsally, coxa I with supracoxal seta. Genital opening with three pairs of acetabula, guarded by a pair of crescentic genital sclerites and a pair of paragenital sclerites; a hemispherical or pedunculate sclerite immediately anterior to the genital opening. Anal sclerites present. A characteristic *Lassenia*-organ anterior to coxa III. Base of gnathosoma with or without setae; supracoxal setae present. Proto-, deuto-, and tritorostral setae all present. Velum simple. Chelicerae slightly to noticeably deflexed posteriorly. Palpi with five free segments, distal margin of trochanter deeply incised on anterior surface. Palpal tibia with heavy terminal seta, at the base of which is a single stout seta. Tarsus of palp with a single solenidion on posterior aspect which may be in either the basal or the distal half of the segment; distal half of the tarsus richly supplied with eupathidia. Eupathidia present on all

segments of all legs beyond the basifemur, sometimes present on ventral surface of telofemur, patella and tibia I. Vestigial setae present on patella I and II and tibia I, but absent on tibia II. Solenidia$_1$, s_2 and s_4 generally indistinguishable, so that in effect only two solenidial types are present on the legs. All tarsi essentially lacking claw fossa; IV without a posterior eupathid in terminal 1/10th of segment.

LARVA: Parasitic upon Diptera living in subaquatic environments. Scutum of known species with a pair of long posterior, and a pair of shorter anterior sensilla, plus two pairs of other setae near the anterolateral and posterolateral corners of plate; anterior sensilla sometimes set off on a minute sclerite separate from the rest of the scutum. Crista absent. Dorsal setae variable in number, borne on individual setigerous sclerites. Ocular plates bicorneate. Coxae I with two pairs of setae, II with one or two pairs of setae, and III with two or three pairs of setae; a well-developed *Lassenia*-organ anterior to coxa III. Urpore present. Anal sclerites with two pairs of setae in known species. Base of gnathosoma with only the supracoxal setae, rostrum with protorostral, deutorostral and tritorostral setae present and well developed. Palpi somewhat geniculate, femur considerably heavier than rest of segments, and sometimes incompletely separated from patella. Tibia with heavy unidentate or bidentate seta at tip. Tarsus of palp elongate, cylindrical, with a single solenidion posteriorly, a terminal and subterminal eupathid. Femur of legs undivided, legs with only five free segments beyond the coxae. Vestigial setae present on patella I, II, and tibia I, but absent from tibia II. Tibia I with two types of solenidia, s_3 and s_4, the latter larger than the former, with distinct internal structure, and a basal companion seta. Solenidion$_1$ also with a basal companion seta, s_2 without a companion seta. Dorsal eupathid of tarsi I and II with a basal companion seta. All tarsi tridactyl, the median claw considerably longer, more slender, and erect than the lateral claws.

TYPE SPECIES: *Lassenia lasseni* new species.

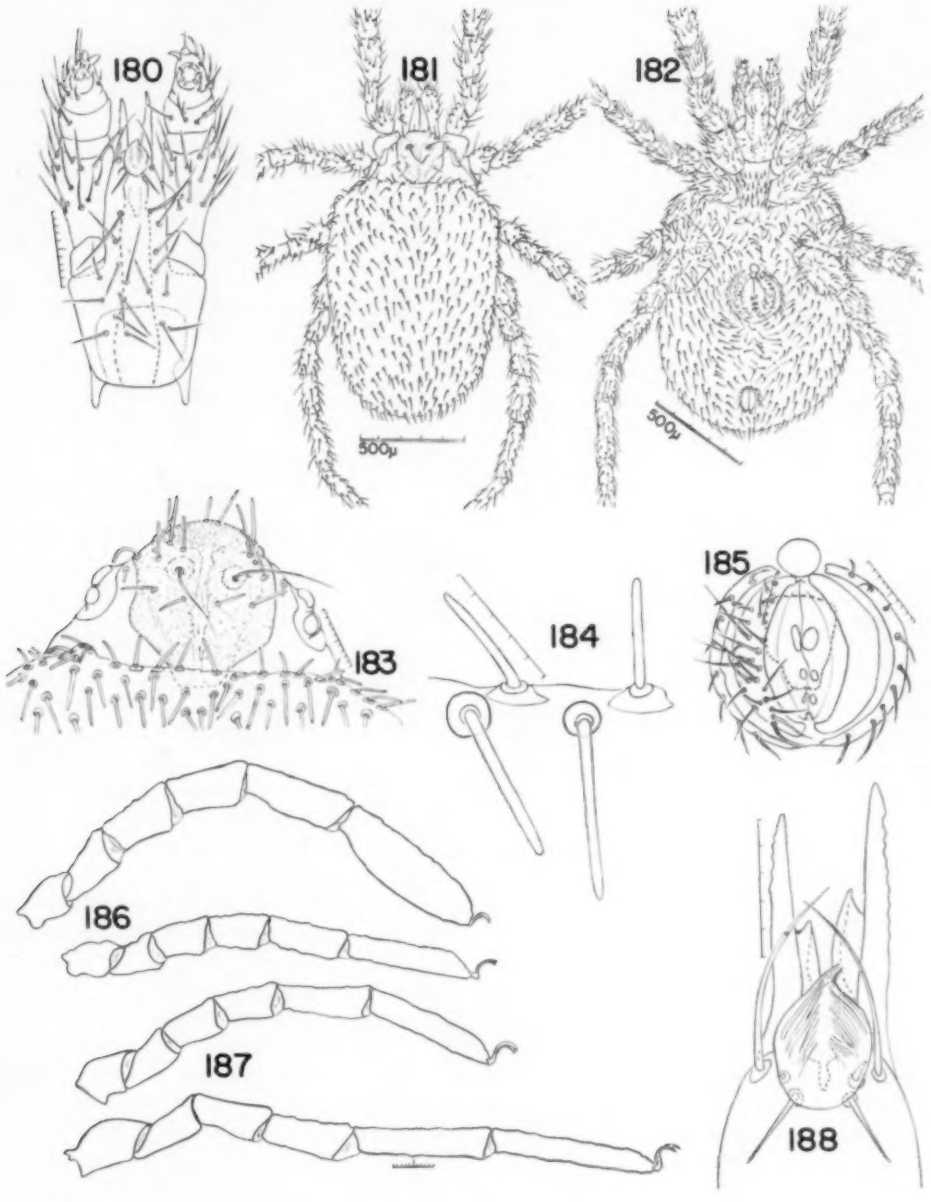
REMARKS: The forms described under this genus have many features in common, but there are also a few in which they differ markedly. It is possible that these may eventually necessitate the creation of a discrete genus for *L. spinifera*, although at present this does not seem necessary.

For a while it was felt that this genus and *Polydiscia* Methlagl 1928 might be identical. Judging from the original description of the latter genus, this might be so, but the possibility is sufficiently remote to make a final decision unwarranted until *Polydiscia squamata* has been fully described.

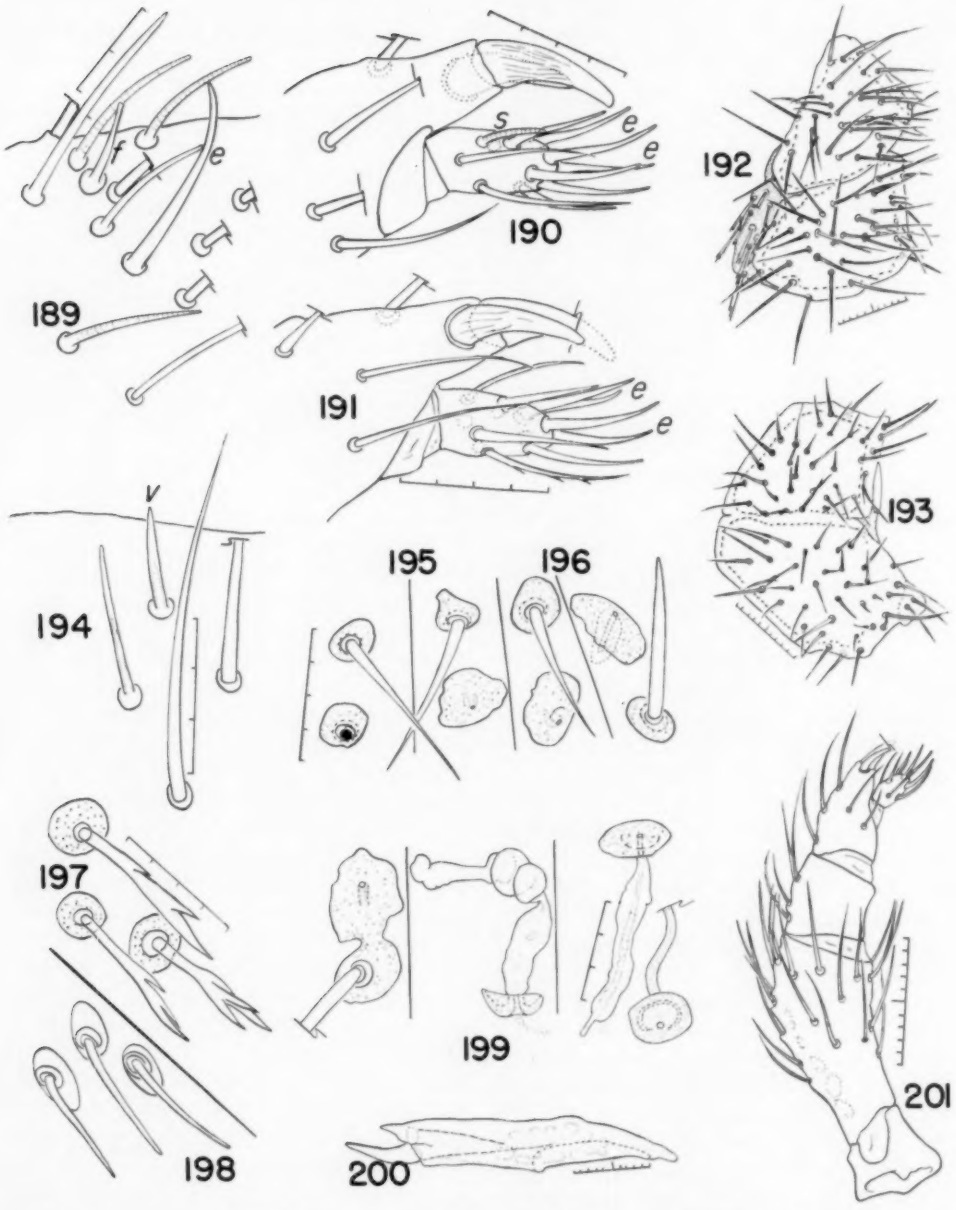
Lassenia lasseni new species

MALE: Body (Fig. 181) 1,534 to 1,716 μ long to tip of propodosoma, 936 to 1,144 μ wide, length/width = 1.44–1.64; average of five specimens 1,628 μ long, 1,066 μ wide, length/width = 1.53. Scutum (Fig. 183) broad, truncate posteriorly, rounded anteriorly, with a single pair of very slender smooth sensilla arising from coarse alveoli. Otherwise with seven to nine stiff, stout, setae on either side of the mid-line; these setae slightly fusiform and smooth. Crista metopica well developed, extending from posterior margin to a point a little more than half way between the alveoli of the sensilla and the anterior margin of the plate. Cuticle of scutum coarsely punctate except for the pale posterolateral portion of the plate. With the exception of the sensilla all of the setae of the scutum are of the same type. Ocular plates well developed and bearing two corneae, the anterior one the larger of the two. A single seta arising from a very minute sclerite between the ocular plate and the scutum; otherwise dorsum of propodosoma devoid of setae. Dorsal body setae (Fig. 184) stiff, smooth, straight, each arising from a small sclerite. Cuticle of dorsum smooth, without striae.

Coxa I (Fig. 192) with 45 to 50 smooth, slender setae plus the short, blunt, spikelike supra-



FIGS. 180–188. *Lassenia lasseni* n. sp., male: 180, gnathosoma, ventral; 181, dorsum; 182, venter; 183, propodosoma; 184, dorsal hysterosomal setae; 185, genital area; 186, legs I and II; 187, legs III and IV; 188, tip of rostrum, ventral.



FIGS. 189–201. *Lassenia lasseni* n. sp.: 189, specialized setae of tarsus I, male; 190, tibia and tarsus of palp, male, posterior; 191, tibia and tarsus of palp, male, anterior; 192, coxae I and II, male; 193, coxae III and IV, male; 194, vestigial and other setae of tibia I, male; 195, *Lassenia*-organ of right and left sides of same male; 196, same, a different male; 197, intercoxal setae, male; 198, ventral hysterosomal setae; 199, *Lassenia*-organ, female; 200, Chelicera, male; 201, palp, male, anterior.

coxal seta; II with 40 to 45 setae. Dorsal portion of both coxae I and II membranous. Pars medialis coxae with 8 to 10 setae, outside of which are 20 to 25 setae in the intercoxal area. All of these plus a very few of the most medial setae of the coxae are two- to four-pronged, and quite stiff (Fig. 197). Apodemes behind II lying in a portion of the cuticle devoid of setae. Just anterior to III is the homologue of the unusual sclerite in the same position in the larva. It is extremely variable in form, but its constancy indicates that it is an important structure. In most cases it appears to be a plate with a gland opening. It is also present in the female. Coxae III and IV with about 40 setae each, all but one or two of which are slender, smooth and tapering; the remaining one or two are faintly barbed (Fig. 193). Cuticle of coxae brown in color, minutely and densely punctate. Genital sclerites (Fig. 185) forming a nearly hemispherical protuberance on the ventral surface of the body; deeply pigmented, each bearing about 24 smooth, slender setae. Paragenital sclerites slender, crescentic, each bearing 7 setae of the same form as those on the genital sclerites. Between the anterior ends of the paragenital sclerites is a hemispherical, deeply pigmented bulla. All sclerites associated with the genital opening minutely punctate. Three pairs of genital acetabula present; penis scarcely more than half the length of the genital sclerites. Anal sclerites well developed but slender, each bearing zero to five smooth setae. Most ventral setae much more slender and tapering than those on dorsum, each borne on a separate minute sclerite. Setae between coxae III of right and left sides of much the same form as those between coxae II, but not quite so heavy (Fig. 198).

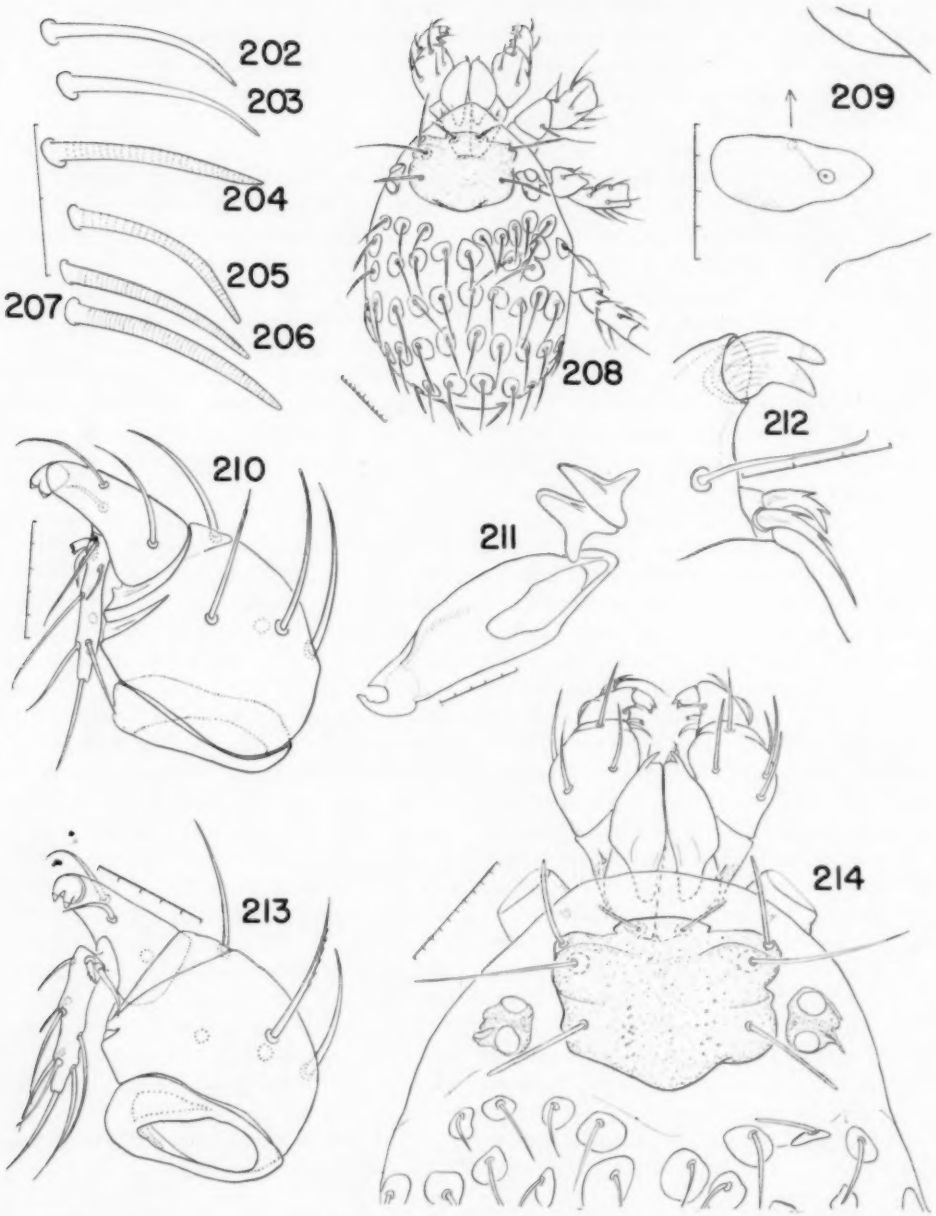
Base of gnathosoma with 12 to 15 smooth slender setae (Fig. 180), rostrum with 7 or 8 more in addition to those at the end of the rostrum. Supracoxal setae rather long (20 to 25 μ), tapering to a sharp point, inserted in the soft membranous dorsal cuticle of the coxae. Velum appearing elliptical in ventral view, inner margin fimbriated. Lateral to the velum is a pair of longer slender protorostral setae directed anteriorly, while just above the posterolateral margin of the velum is a pair of small spikelike deutorostral setae and a longer pair of tritorostral setae oriented in a posteroventral direction (Fig. 188).

Chelicerae (Fig. 200) relatively long and slender, heavily sclerotized, cuticle densely punctate; tarsus with 14 to 15 very minute teeth visible under high magnifications; cheliceral membrane pointed, extending to about middle of tarsus. Palpi (Fig. 201) relatively long, slender, straight. Trochanter devoid of setae, anterior aspect fenestrated. Femur with 29 to 30 setae, patella with 9 to 10 setae, anterior surface bare; tibia with about 10 normal setae plus the heavy spiniform terminal and subterminal setae. Tarsus (Figs. 190, 191) with an annulate solenidion at 0.4 to 0.5*pd*, six to eight large eupathidia on distal half of segment and two to six normal setae (quite variable). All normal setae of palp appearing smooth at low magnification (100 x), but at higher magnifications a few very minute barbs can be seen on some of the setae. No tracheal openings could be seen on the dorsum of the gnathosoma in the position normally occupied by these, and no tracheae could be seen internally.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, n = normal setae, m = many).

Eupathidia present dorsally or marginally

	tf	pa			ti				ta					
	e	s_2	e	v	s_2	s_4	e	v	s_1	s_4	s_2	s_3	e	f
I	2	7	4	1	27	0?	5,7	1	(——m——)			0	m	1
II	1	4	3	1	10	1	2	0	(–13–)		1	0	4	1
III	1	5	2	0	10	0	1	0	0	8	0	0	3	0
IV	1	6	2	0	8	0	1	0	0	10	0	0	3	0



FIGS. 202–207. *Lassenia lasseni* n. sp., female: 202, solenidion$_2$, tibia I; 203, s_2, patella I; 204, s_1, tarsus I; 205, s_4, tarsus III; 206, s_3, tarsus II; 207, s_2, tarsus II.

FIGS. 208–214. *Lassenia lasseni* n. sp., larva: 208, dorsum; 209, *Lassenia*-organ; 210, palp, posterior; 211, chelicera and apodemes; 212, distal seta of tibia and basal seta of tarsus of palp; 213, palp, anterior; 214, propodosoma.

on all segments of all legs beyond the basifemur, none ventral, except on the tarsi. Vestigial setae present only on patella I and II and tibia I. Famulus of tarsus I at 0.55*pd*, famulus$_2$ at 0.62 to 0.79 (this variation was noted on the right and left sides of a single male). Eupathidia of tarsus I extending from 0.17*v* to 0.17*d*, claw fossa absent. Eupathidia of tarsus II extending from 0.43*d* to 0.97*v*; tarsus tapering rapidly beyond 0.75*d*, but no true claw fossa present. Tarsus III with eupathidia at 0.41*d*, 0.64*p*, and 0.96*pv*; IV with eupathidia at 0.43*d*, 0.48*d*, and 0.67*p*, none near end of tarsus. Solenidia of tarsi difficult to interpret because of convergence in form, especially between types s_1, s_2, and s_4. No solenidia referable to type s_3 found on the tarsi. Tarsus II with a somewhat heavier solenidion, presumably s_2, at 0.47*d*, plus about 12 others presumably s_1 or s_4 or both. Claws of all tarsi simple, smooth, scythe-shaped.

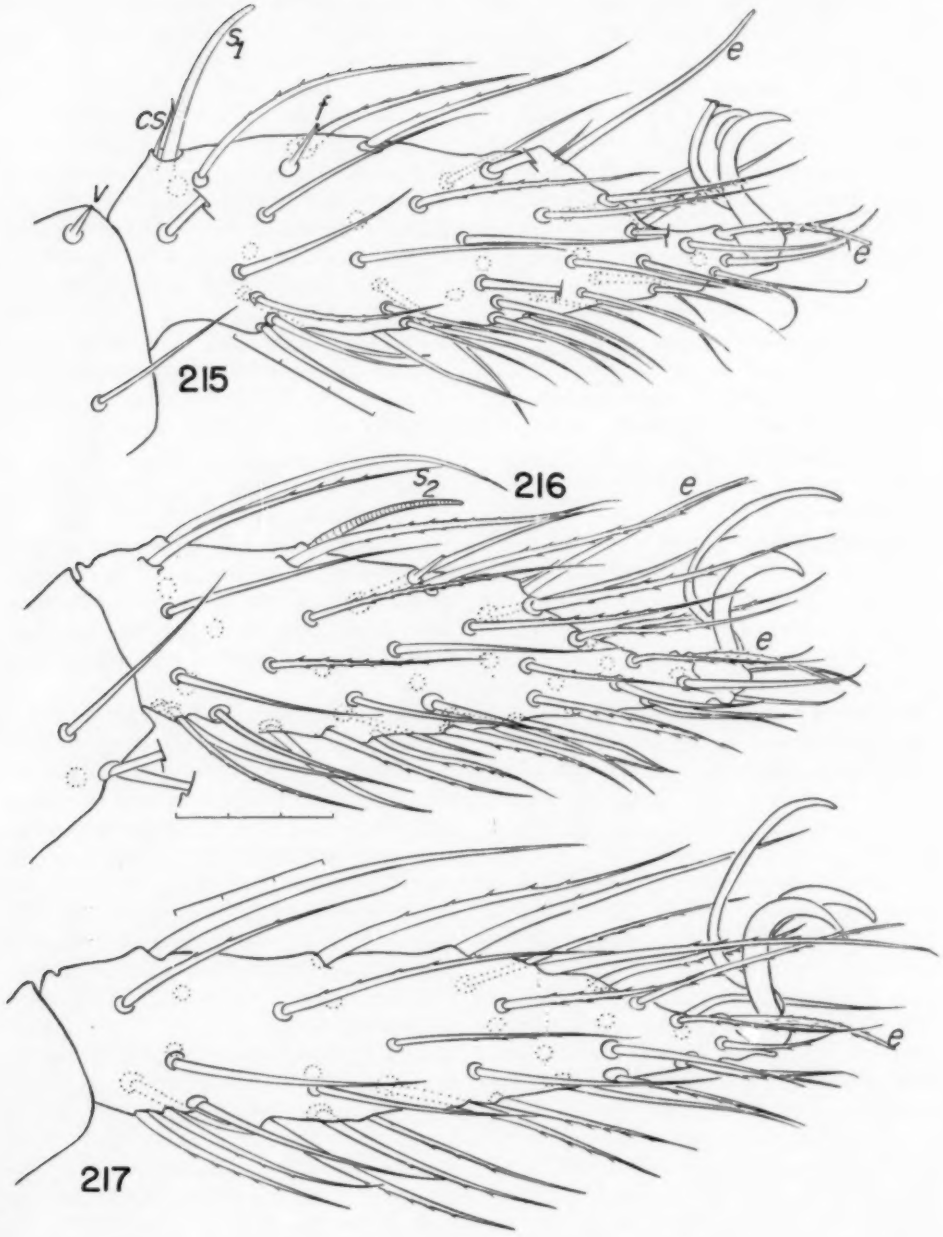
FEMALE: Body 1,378 to 2,574 μ long, 806 to 1,872 μ wide, length/width = 1.38 to 1.71; average of six specimens 1,846 μ long, 1,235 μ wide, length/width = 1.50. Resembling the male in virtually all respects, even the genital sclerites and paragenital sclerites being only slightly larger and with possibly a very few more setae than in the male. Genital acetabula distinct, the anterior pair the largest. Anal sclerites also as in male.

LARVA: Body (Fig. 208) 522 to 576 μ long in partially engorged specimens. Scutum (Fig. 214) with anterior sensilla short, stiff and faintly pectinate; posterior sensilla very long, slender, smooth, uniformly tapered. Setae at anterolateral and posterolateral angles of scutum stiff, faintly roughened. Ocular plates with two distinct corneae. Cuticle of ocular plates and of scutum faintly punctate. Crista metopica completely absent. With 48 to 53 dorsal and marginal setae each borne on individual sclerites in the two specimens examined; lateral setae more slender than the others. Cuticle of dorsum without striae.

Coxae I and II with two setae each, III with three (occasionally four) simple smooth setae; intercoxal area completely devoid of setae. Coxae I and II close together, urpore well developed; a structure of unknown nature (the "*Lassenia* organ," Fig. 209) laterally between II and III. Under oil immersion this appears to be a plate of much the same form as the setigerous sclerites, with the cuticle faintly punctate, and with an alveoluslike structure on the inner half of the plate. Near the center of this alveoluslike structure is a minute pore about 0.9 μ in diameter, which opens into a delicate chitinous duct about 22 μ long. At its inner end this duct expands to form a delicate cup or sphere approximately 3.6 μ in diameter. The duct is not hydrolyzed by the enzymes used to clear the mites.

Supracoxal setae present in the membranous dorsal portion of coxa I, but absent on II and III. Postcoxal area with 23 to 27 setae exclusive of those borne on the anal sclerites, all of these setae arising from individual feebly developed sclerites with faintly punctate cuticle (Fig. 221). Anal sclerites moderately developed, with two to three pairs of setae.

Base of gnathosoma (Fig. 229) devoid of setae, cuticle densely and minutely punctate, posterior half partly divided by vertical chitinous septum. Protorostral and tritorostral setae long and slender, deutorostral setae short and spikelike, posterorostral setae absent. Supracoxal setae rather long and uniformly tapered. Velum very delicate, semicircular in form, consisting of a fimbria of extremely delicate chitinous processes extending inward toward the mid-line at the tip of the rostrum. Chelicerae (Fig. 211) with digitus mobilis a soft membranous process, tarsus with distal portion slender, scythe-shaped, of fairly uniform thickness throughout most of length, and typically with two small teeth near the end of the tarsus. Trochanter of palp (Figs. 210, 213) very short, ringlike, lacking setae. Femur greatly swollen and bearing five smooth setae on dorsal and posterior aspects. Patella incompletely separated from femur posteriorly (Fig. 210); with a single dorsal



FIGS. 215–217. *Lassenia lasseni* n. sp., larva: 215, tarsus I, posterior; 216, tarsus II, posterior; 217, tarsus III, posterior.

seta. Distal portion of tibia curved sharply toward median line (Fig. 214); three pairs of smooth normal setae plus the greatly enlarged bifid distal seta. The latter is marked with somewhat irregular longitudinal striae (oil immersion, Fig. 212) and the two teeth are hollow in the distal half. Tarsus with two strongly curved, usually barbed heavy setae at base, a solenidion at 0.25 to 0.33*p*, one terminal and one subterminal eupathid; otherwise with five smooth, normal setae. Podocephalic canals reaching from cheliceral apodemes to, or nearly to, the urpore; a number of branches present.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathida, f = famulus, v = vestigial setae, c = companion setae, n = normal setae).

Femora I to III undivided (Figs. 218–220). Patella I and II with a vestigial seta dorsally. Tibiae with vestigial seta present only on I but with numerous solenidia dorsally as shown in the accompanying table; normal setae also abundant. Solenidion$_4$ on tibia I is longer, larger, and different in structure from the solenidia$_3$; moreover it has a companion seta at the base. Tarsus I with s_1 at 0.08 to 0.10*d* and a large eupathid at 0.64 to 0.69*d*, each with a companion seta; famulus at 0.24 to 0.27*pd* and a second eupathid at 0.91*pd*. The famulus is borne on a vesicular alveolus and is flattened and expanded at the tip (Fig. 228). Tarsus II with a delicately annulate solenidion at 0.34 and a eupathid with companion seta at 0.65*d*. Famulus like that on I but at 0.49*pd;* a second eupathid at 0.90*pd*. Tarsus III with a single eupathid at 0.91*pd* but with no other specialized setae. Most of the normal setae of the legs are delicately pectinate. All tarsi with three claws, the median one longer and more slender than the lateral ones.

TYPE LOCALITY: Mount Lassen, California, in a small cascade stream about one mile above Hat Lake; elevation about 7,250 feet (holotype male). July 9, 1954, and August 7, 1955. I. M. Newell, collector. Also collected at headwaters of Kings Creek, Mt. Lassen, California, August 6, 1955, by the writer.

REMARKS: This species can be differentiated from *L. scutellata*, new species, by the much larger number of setigerous sclerites on the dorsum (*L. scutellata:* only about 20 dorsal and marginal setae), the bifid form of the terminal seta of the palpal tibia (*L.s.:* this seta not bifid), and by numerous points of difference in the chaetotaxy of the legs which will be apparent by a comparison of the tables and descriptions given for the two species.

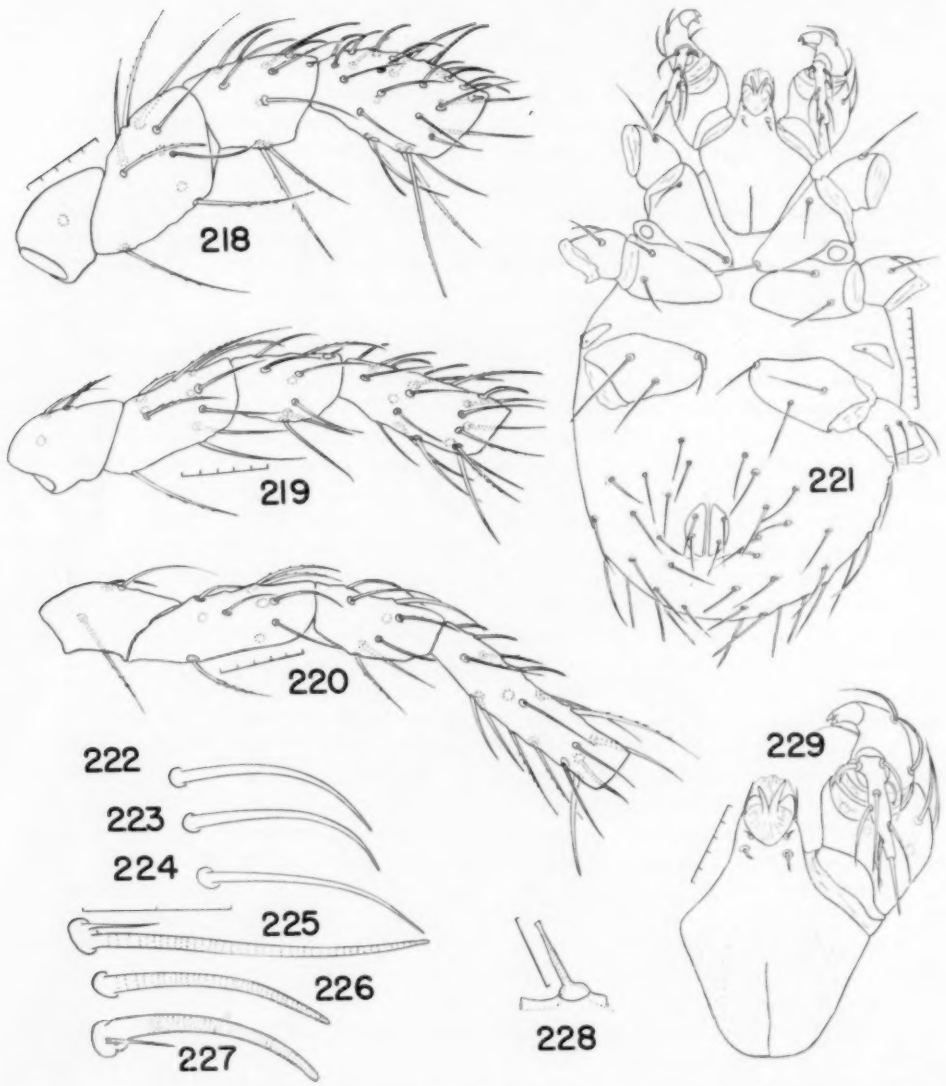
Lassenia lasseni is definitely a cold-stenothermal species and its distribution is undoubtedly limited by this fact. The larvae are parasitic upon small species of Diptera resembling Drosophilidae, found breeding along the banks of mountain streams. They are of the self-detaching type.

The correlation between the larva and adult of this species has been established solely on the basis of their occurrence at the same locality. While the correlation is to a certain degree provisional, it is reasonably certain that the two forms are conspecific. In all, 9 larvae, 6 nymphs, and 25 adults were collected at this location, and there is no indication that more than one species is involved in the collection. The species is not as common as the above numbers might indicate, for this represents the total catch of about 15 hours of hand collecting over a three-day interval. The adult was first collected July 9, 1954, and larvae and adults were found August 7, 1955.

Lassenia spinifera new species

FEMALE: Two specimens available for study

	tr	fe	pa			ti					ta					
	n	n	s_3	v	n	s_3	s_4	v	c	n	s_1	s_2	e	f	c	n
I	1	10	2,3	1	8	12	1	1	1	16	1	0	2	1	2	50
II	3	10–12	0	1	8	4,5	0	0	0	17	0	1	2	1	1	43
III	3.4	9,10	0	0	8	3	0	0	0	15	0	0	1	0	0	40



FIGS. 218–229. *Lassenia lasseni* n. sp., larva: 218, leg I, trochanter to tibia; 219, leg II, trochanter to tibia; 220, leg III, trochanter to tibia; 221, venter; 222, solenidion$_2$, tibia I; 223, s_2, patella I; 224, s_3, tibia III; 225, s_4, tibia I; 226, s_2, tarsus II; 227, s_1, tarsus I; 228, famulus$_1$, tarsus I; 229, gnathosoma.

measured 1,326 and 1,794 μ to tip of scutum, 637 μ to 832 μ wide (length/width 2.08, 2.16). The smaller specimen was evidently an immature female and even the larger one was nonovigerous. Scutum (Fig. 232) much more elongate than in the type species of the genus, and with a distinct anterior spine (hence the name). A pair of very elongate, slender,

smooth sensilla at or slightly behind the middle of the plate and a pair of much shorter setae near the base of the spine. These are of the same general form as the other setae of the dorsum of the propodosoma, but their position and orientation indicate that they are the anterior sensilla. Their alveoli are indistinct and very small in contrast with those of the other dorsal propodosomal setae which are well formed. Limit of scutum indistinct in anterolateral portions where it is all but impossible to trace in undissected specimens. Crista metopica well developed up to a point about half way between the posterior and anterior pairs of sensilla. Ocular plates elongate, bearing two pairs of prominent corneae, the posterior of which are the larger. In addition to the sensilla, the dorsum of the propodosoma bears 23 to 37 smooth, slender tapering setae on each side, 8 to 15 of which are definitely outside the scutum and 13 to 20 are definitely inside the scutum; one to three setae near the anterolateral margins of the scutum of uncertain position. Dorsal hysterosomal setae markedly different from those of the propodosoma, resembling those of *Lassenia lasseni*, stiff, rodlike, each borne on a small sclerite visible under high magnification (Fig. 246). The sclerites are not noticeably elevated. Membranous cuticle of hysterosoma completely smooth.

Coxae I with 65 to 75 smooth setae each (Fig. 234) plus the short peglike supracoxal seta in the membranous portion of the dorsal surface of the coxa. Coxa II with 35 to 50 setae; dorsal wall of distal part of coxa not sclerotized, but membranous like I. Both coxae I and II devoid of setae on their medial aspects. Intercoxal area with about 70 to 75 long stiff setae arranged in a rather characteristic radiating pattern; pars medialis coxae completely absent. Behind the sclerotized part of coxa II is a single to triple row of setae like those on the coxae, behind which is the usual transverse band of membranous cuticle devoid of setae. The presence of setae in the membranous area directly behind coxa II, and the absence of the pars medialis coxae indicate a considerable reduction in the degree of sclerotization of the coxae of this species. While the specimen studied was not a completely matured female, it seems probable that the conditions described above would be found in ovigerous females also. Coxae III with 30 to 36 setae, IV with 65 to 75 setae (Fig. 244). Genital sclerites moderately well developed but not of the strongly crescentic form found in *Lassenia lasseni*, bearing 21 or 22 setae in a single to double row (Fig. 233). Paragenital sclerites very feebly developed, scarcely visible at low magnification, but at higher magnifications apparent as a slight change in texture of the cuticle; each sclerite bearing 12 to 15 setae. Anterior to the genital opening is the characteristic bulliform structure found also in the type species of the genus, and just anterior to this is a very small, transverse sclerite. Three pairs of genital acetabula present. The ventral body setae surrounding the genital opening are largely oriented in the direction of the genital opening, while the setae on the genital and paragenital sclerites are mostly oriented in a more ventrad direction. Anus (Fig. 240) completely terminal, anal sclerites fairly well delimited, weakly crescentic, bearing 16 to 17 setae each. Ventral hysterosomal setae borne on minute sclerites; shaft of seta considerably more slender and tapering than in the case of the dorsal setae, the two types intergrading laterally. Ventral cuticle mostly smooth, with only scattered traces of striations. Two small apodemes in the transverse strip of cuticle behind each coxa II. No trace of the characteristic gland found anterior to coxae III in the adults of *Lassenia lasseni* was seen in this species, but the material was not entirely favorable for study of this feature.

Base of gnathosoma (Fig. 248) totally devoid of setae, except for the supracoxals. Rostrum with four pairs of setae as shown in Figure 235. Deutorostral setae short and peglike, concealed behind the margin of the velum in ventral view. The lateral arms of the

gnathosoma are quite elongate. Chelicerae (Figs. 245, 247) with posterior end bent rather sharply downward; tarsus with about four dorsal teeth in distal half, and four to five subdorsal teeth in basal half. Palpi (Fig. 242) considerably larger and relatively thicker than in *Lassenia lasseni* (Fig. 201). Anterior aspect of trochanter deeply dissected, but the sclerotization of the femur extends deep into this, so that the fenestration of the anterior wall of the trochanter is markedly reduced; left trochanter of holotype female with, right trochanter without, a seta on posterior aspect. Femur with 51, patella 36, and tibia with 27 smooth slender setae in the single specimen studied, plus the large terminal and smaller subterminal spiniform setae on the tibia. The terminal seta of the tibia is unidentate. Tarsus (Fig. 238) with a single solenidion at 0.88*pd*, this showing faint spiral structure and a somewhat swollen base. Proximal two-thirds of tarsus with 24 normal setae like those on the other segments of the palp; distal one-third of tarsus with 15 eupathidia showing distinct annulate structure internally. The eupathidia are somewhat heavier than the solenidion, and the curvature of the two types of setae is reversed.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, n = normal setae, m = many).

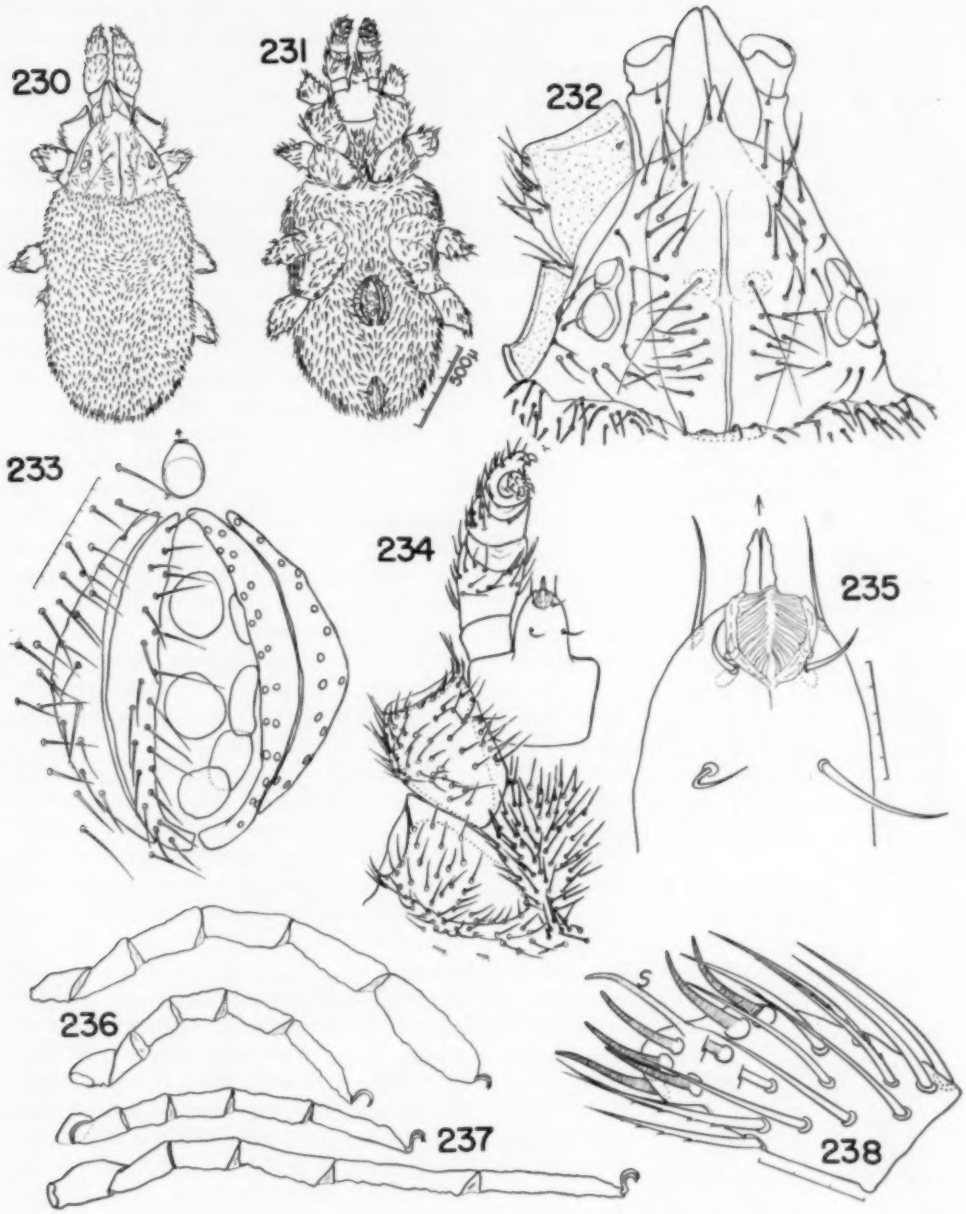
All solenidia of patella and tibia of all legs of s_3 type, except for one questionable s_4 on tibia I and II. Tarsus I with famulus at 0.80*pd* and many eupathidia extending from 0.13*v* to 0.17*d;* six or seven s_3 near the base of the tarsus, but all of the other many solenidia are more or less of the same form and size, so that it is impossible to differentiate the types with certainty. End of tarsus I rather abruptly cut off, beginning at about 0.90*pd;* claw fossa absent. Tarsus II with famulus at 0.67*pd*, and about five eupathidia between 0.17*d* and 0.97*pv;* no ventral eupathidia. One seemingly distinct s_2 at 0.36*d*, one or two s_3 near the base of the tarsus, and two or three other solenidia of indeterminable type (s_1 or s_4). Tarsus II tapering rather abruptly from about 0.67*d* to the end of the segment, claw fossa absent. Tarsi III and IV each with about five s_3 or s_4; III with five eupathidia ranging from 0.19*d* to 0.95*v*, IV with an equal number ranging from 0.18*d* to 0.79*v*, terminal eupathid lacking. All tarsi with two heavy claws faintly hirsute along convex margin.

Telofemora well supplied with eupathids especially on I. Telofemur, patella, and tibia I notable in that the majority of the eupathidia are ventral in position. Of the 10 counted on telofemur I, 6 were dorsal or marginal in position, while 4 were ventral; of the 18 counted on patella I, 6 were dorsal or marginal while 12 were ventral; and of the 32 on tibia I only 8 were dorsal or marginal in position while 24 were ventral. These figures, like the rest of the figures in the accompanying table were based on counts made on a single specimen. Vestigial setae only on patella I and II and on tibia I; no vestigial seta on tibia II. All eupathidia on the telofemur, patella, and tibia of legs II to IV either dorsal or marginal in position, none ventral.

Lassenia scutellata new species

LARVA: Body (Fig. 249) 387 μ long, 243 μ wide, length/width 1.58 (one specimen only). Scutum subrectangular in form, divided into a small anterior portion bearing the anterior sensilla, and a much larger posterior portion bearing the posterior sensilla and other setae.

	tf	pa			ti				ta					
	e	s_3	e	v	s_2	s_4	e	v	s_2	s_1	s_4	s_3	e	f
I	10	13	18	1	54	1?	32	1	(——m——)				7±	m	1
II	3	7	4	1	8	1?	6	0	1	(–2,3–)		1,2	5	1
III	2	7	6	0	9	0	5	0	0	0	(–4,6–)		5	0
IV	1	8	8	0	17	0	6	0	0	0	(–4,6–)		6	0



FIGS. 230–238. *Lassenia spinifera* n. sp., female: 230, dorsum; 231, venter; 232, propodosoma; 233, genital area; 234, gnathosoma, coxae I and II, and intercoxal area; 235, tip of rostrum; 236, legs I and II; 237, legs III and IV; 238, tarsus of palp, posterior.

Cuticle of scutum slightly punctate; crista absent. Anterior sensilla only about half as long as posterior sensilla; scutum otherwise with two other pairs of setae. All setae of scutum with a few very minute barbs visible only under high magnification (400 x or higher). Ocular plates with two well-developed corneae, separated from the scutum by a narrow interval of striated cuticle. Dorsal and marginal setae numbering 20 pairs; venter with 7 pairs of ventral setae excluding those on the anal plates. Membranous cuticle of both dorsum and venter distinctly marked with striae which for the most part are parallel.

Coxae I (Fig. 251) each with two setae ventrally and a small inconspicuous supracoxal seta; II with one, III with two setae. Between coxae I and II is a large well-developed urpore and anterior to coxa III at the margin of the body, a large sclerite obviously comparable with that found in *Lassenia lasseni*, new species. In the sole specimen available the soft parts were not very well hydrolyzed and a glandlike mass of cells can be seen extending up to the inner surface of the plate. Intercoxal area devoid of setae; postcoxal area with seven pairs of ventral setae surrounding the well-defined anal sclerites which bear an additional two pairs of slender setae.

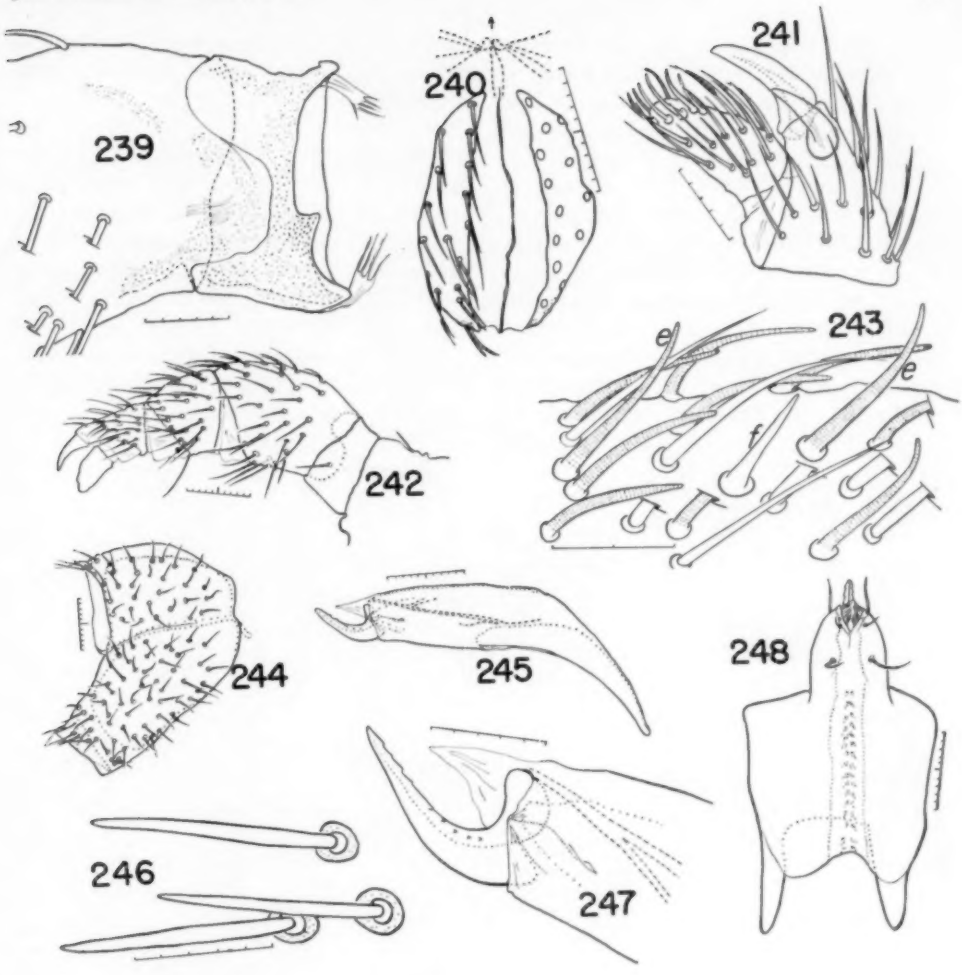
Base of gnathosoma as described for *Lassenia lasseni*. Podocephalic canals probably present but not visible because of opacity of specimen. Supracoxal setae present, structure of velum obscured by organic accretions evidently resulting from feeding activities of mite; protorostral, deutorostral and tritorostral setae present, posterorostrals absent.

Chelicerae (Fig. 261) essentially as in *Lassenia lasseni;* tarsus with two teeth dorsally (not visible in figure because of rotation of chelicera). Cuticle of chelicerae faintly and sparsely punctate, with parallel longitudinal striae dorsally. Palpi (Fig. 265) distinctly five-segmented, trochanter and femur completely separated, not partially fused as in *Lassenia lasseni*. Trochanter very short, ringlike, femur bearing only two setae, one dorsally and one anteriorly. Patella wedge-shaped, bearing a single long seta dorsally; tibia with only three very slender slightly pectinate setae in addition to the heavy terminal toothlike seta; the latter is not bifid at the tip but the microscopic structure of the hollow tip appears identical with that of the type species. Tarsus of palp with a distinctly annulate solenidion at 0.28*p*, one eupathid at 0.69*d*, and a second one terminally, otherwise with nine normal setae. The most basal of the latter is rather sharply deflexed and heavily pectinate, but it is not short and stout as in the genotype. Base of tarsus also with a pitlike structure dorsally, the exact nature of which is not known.

Chaetotaxy of legs approximately as shown in table (s = solenidia, e = eupathidia, f = famulus, v = vestigial setae, c = companion setae, n = normal setae).

Chaetotaxy of legs differing in numerous specific respects from *Lassenia lasseni*. Trochanters I to III (Figs. 262–264) with a single seta each. Femora with no trace of subdivision, so that the legs have only five free segments as in the type species. Patella I and II with vestigial seta of the same form as found on tibia I (Fig. 257). Tibia I with, II without a vestigial seta; tibiae not so richly supplied with solenidia$_2$ as in the case of *Lassenia lasseni*, there being only four on tibia I. Tibia I with a solenidion$_4$ at 0.72*d*, but II and III with only the solenidia$_3$. Tarsus I with s_1 and companion setae at 0.27*d*, a smooth, elongate spikelike famulus at 0.68*pd*, a eupa-

	tr	fe	pa			ti					ta					
	n	n	s_2	v	n	s_3	s_4	v	c	n	s_1	s_2	e	f	c	n
I	1	6	2	1	5	4	1	1	1	8	1	0	2	1	2	36
II	1	6	1	1	4	2	0	0	0	9	0	1	2	1	1	29
III	1	5	1,0	0	4	1	0	0	0	8	0	0	1	0	0	24



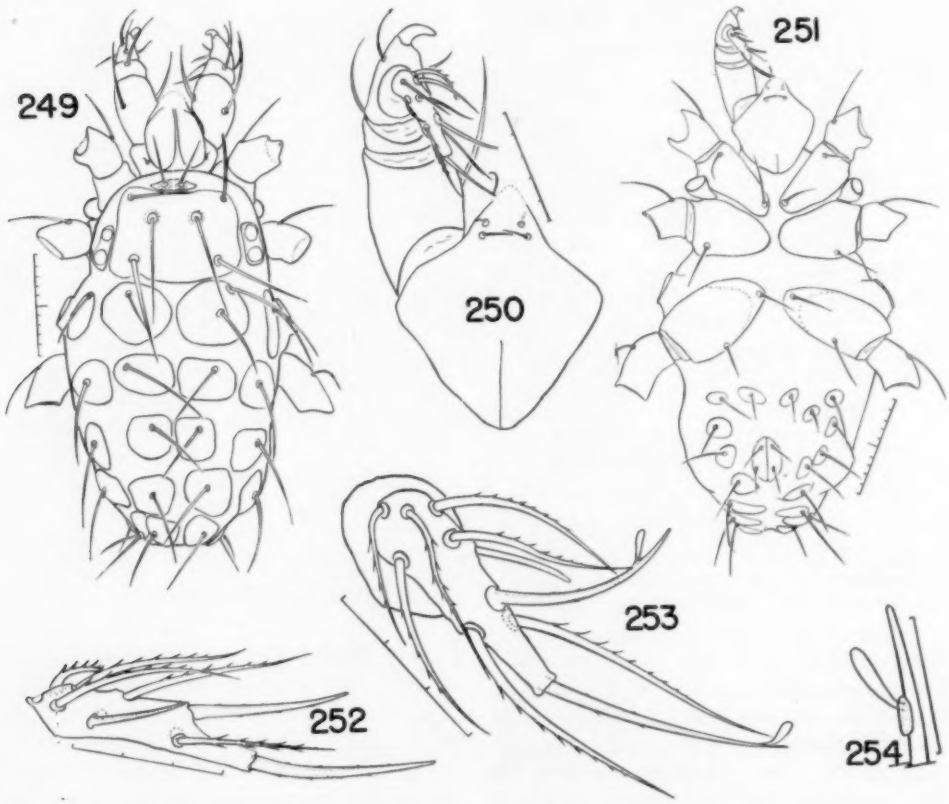
FIGS. 239–248. *Lassenia spinifera* n. sp., female: 239, trochanter and femur of palp, anterior; 240, anus; 241 tibia and tarsus of palp, anterior; 242, palp, posterior; 243, tarsus I, showing setal types; 244, coxae III and IV 245, chelicera; 246, dorsal hysterosomal setae; 247, end of chelicera; 248, gnathosoma, ventral.

thid and companion seta at 0.71*ad* and a second eupathid at 0.92*p* (Figs. 255, 258, 260). The famulus is inserted on a somewhat vesicular alveolus, but this is not as prominent as in *L. lasseni;* moreover, the tip of the famulus tapers to a fairly sharp point and is not expanded at the tip as it is in the type species. Tarsus II with s_2 at 0.40*d*, famulus at 0.61*d* of the same form as found on tarsus I, a peripectinate eupathid and companion seta at 0.67*d* and a second eupathid at 0.94*p*. Tarsus III with a single eupathid at 0.92*p*. Most normal setae of legs bihemipectinate, the pectinations visible at magnifications of 200 x and higher; total number of normal setae on legs about 145, compared with 240–245 in *L. lasseni*. Other features of chaetotaxy as shown in the accompanying table. Three

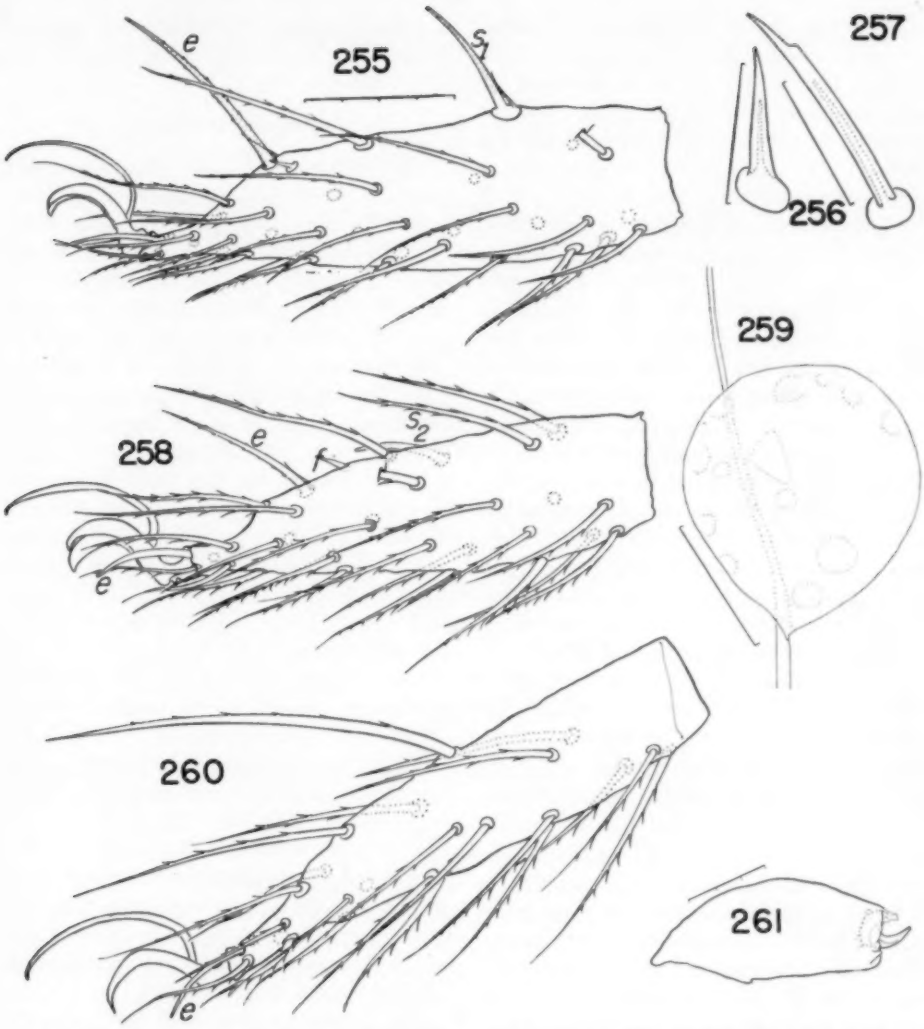
claws on all tarsi, the median claw considerably more slender and erect than the lateral claws; lateral claws with a fringe of hairs along the outer margins, median claw also appearing hirsute under oil immersion.

TYPE LOCALITY: Spencer's Butte, Eugene, Oregon (holotype larva). The type and only specimen was found in material beaten from shrubs, July 10, 1952, collected by the writer. Since *Lassenia lasseni* has larvae of the self-detaching type, it is probable that the present species has this same habit. Therefore it is impossible to say whether the larva was actually crawling on the shrubs or whether it was attached to a host insect which happened to be on the shrubs. It had obviously been feeding.

REMARKS: It is possible that this is the larva of *L. spinifera*, but since the locality records for the two are quite different, it is best not to correlate the larva and adult at this time. *L. scutellata* and *L. spinifera* are at present known only from the state of Oregon. *L. scutellata* can be readily differentiated from *L. lasseni* on the basis of the characters discussed under the remarks following the description of the type species.



FIGS. 249–254. *Lassenia scutellata* n. sp., larva: 249, dorsum; 250, gnathosoma; 251, venter; 252, tarsus of palp, posterior; 253, tarsus of palp, distidorsal; 254, cyst-like object of unknown nature attached to palpal eupathid, probably fungus or protozoan.



FIGS. 255–261. *Lassenia scutellata* n. sp., larva: 255, tarsus I, posterior; 256, famulus$_1$, tarsus I; 257, vestigial seta, tibia I; 258, tarsus II, posterior; 259, organism of unknown nature attached to seta at base of femur I; 260, tarsus III; 261, chelicera.

Polydiscia Methlagl 1928

The resemblance between the larva of *Polydiscia squamata* Methlagl 1928 and that of *Lassenia scutellata* n. sp. is so close as to leave little doubt of the very close relationship between *Polydiscia* and *Lassenia*. The genus must therefore be removed to the Johnstonianidae. Thor and Willmann (1947, p. 342) placed the genus in the Trombiculinae, Radford (1950, p. 99) placed it in the Microtrombidiinae, and Baker and Wharton (1952, p. 251, *Polydisca, sic*) listed it with the Trombidiidae whose subfamilial relationships are unknown.

The major points of similarity to *Lassenia* are the presence of two pairs of sensilla on the scutum (not a single pair as assumed by various authors), the large setigerous sclerites covering the dorsum, the 2–1–2 setal formula of the coxae, the presence of distinct setigerous anal sclerites, and the tridactyl tarsi of the larva. There are however, certain differences such as the apparently rectangular form of the base of the gnathosoma, the simple form of the palpi, the absence of a clawlike seta on the tibia of the palp and the subdivision of the femora of the legs, (provided these were all accurately represented in the original descriptions, which is improbable).

The fact that the anterior pair of setae of the scutum were not considered sensilla undoubtedly stems from the weak development of the alveoli of these setae. Precisely the same situation is found in *Lassenia scutellata* (Fig. 249), although close study of these setae at high magnification shows that they do have somewhat more elaborately developed alveoli than do the other setae of the scutum. The anterior setae of *Lassenia lasseni* are even less sensillar in form, although there is no doubt whatever that these are the true homologs of the anterior sensilla of such forms as *Diplothrombium*.

Thor and Willmann (1947, p. 343) stated that this was "wahrscheinlich ein Trombidioseerreger." Methlagl (p. 247) stated that *Polydiscia squamata* was responsible for trombidiasis in the vicinity of Vienna, although he earlier (p. 225) indicated that he had never found it on any host. Apparently the correlation between trombidiasis and *Polydiscia* was based solely on the seasonal abundance and general appearance of the latter. But this type of correlation can lead to absurd results as Methlagl himself (p. 247) so clearly showed when, on similar evidence, he supposed *Hauptmannia longicollis* Oudemans to be the larva of *Anystis vitis* (Schrank). For the present we can only conclude that *Polydiscia squamata* has not been shown to play any role in trombidiasis of man. On the contrary, its similarity to *Lassenia scutellata* (and hence to *L. lasseni*) is good presumptive evidence that larvae of *P. squamata* are parasites of insects and not of vertebrates.

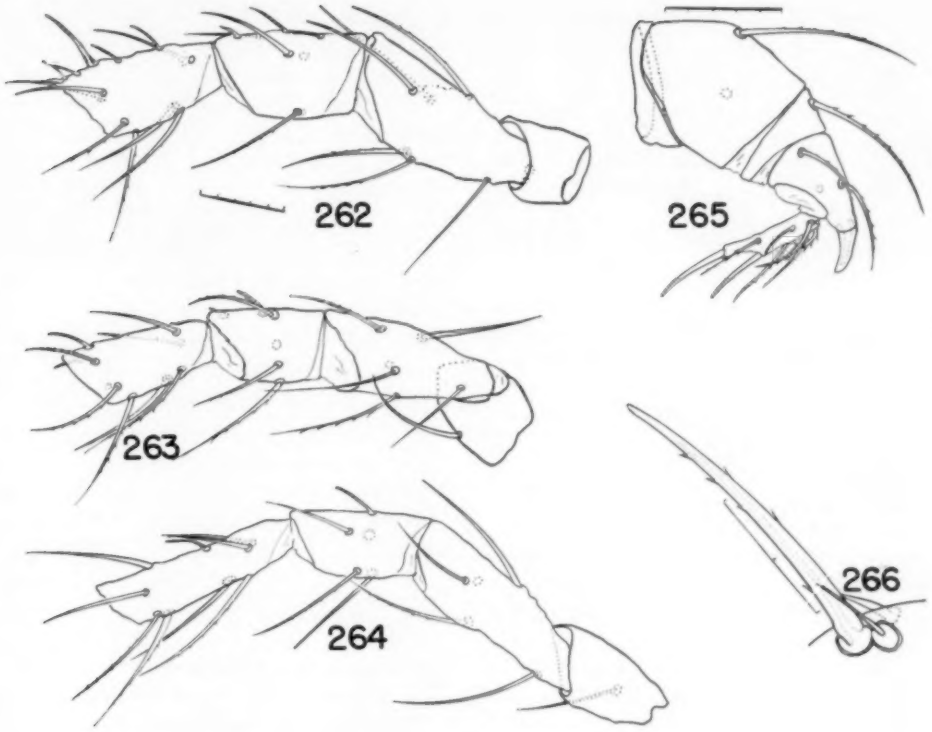
Crossothrombium Womersley 1939

This South Australian genus has been generally overlooked in recent catalogs (Thor and Willmann, 1947; Radford, 1950; Baker and Wharton, 1952). As Womersley pointed out, it is allied to *Johnstoniana*, and therefore belongs in the Johnstonianidae. However, contrary to Womersley's diagnosis, the holotype, *Crossothrombium parkhousei* Womersley 1939, appears to have two pairs of sensilla. The anterior pair, as in the case of *Lassenia*, is appreciably different from the posterior pair, but nevertheless they must be regarded as the homologs of the anterior sensilla. Womersley indicated that the eyes are absent which would be a significant point of difference between this genus and all of the others of Johnstonianidae. He also indicated that the dorsal setae arise from large "pits or circles," which are evidently the setigerous sclerites so typical of the Johnstonianidae. The tarsus of the palp was described as being "without terminal spines." If "spines" in this case means eupathidia, this would be unique in the family. This, too, requires verification. The description of both the genus and the species are too fragmentary to permit comparison with other genera of the family. One of the characters that can be seen in the figures is that there are several setigerous sclerites lying lateral to the scutum.

The species was described from a single specimen collected in South Australia, and was subsequently recorded from Victoria, Australia (Womersley 1942, p. 172).

Myrmicotrombium Womersley 1934

The original diagnosis of this genus was as follows: "Crista short, with two sensillary areas at anterior and posterior end. One eye on each side, in front of the anterior end of crista. Body as in *Microtrombidium*. Tarsi at end truncate, with one or two small, raised prom-



FIGS. 262–266. *Lassenia scutellata* n. sp., larva: 262, leg I, trochanter-tibia; 263, leg II, trochanter-tibia; 264, leg III, trochanter-tibia; 265, palp, posterior; 266, dorsal eupathid, famulus, and companion seta, tarsus I.

inences from which arise plain setae." Womersley pointed out in his remarks that the presence of two pairs of sensilla on the scutum indicated a relationship to *Diplothrombium* and also to *Johnstoniana* (= *Rohaultia*). However, a study of his figure of the scutum shows that this is in no way similar to the scutum of either *Diplothrombium* or of *Johnstoniana*. In fact it is very suggestive of the scutum of Erythraeidae such as *Balaustium*. Likewise the sharply cutoff form of the tarsus, with the distal face of the tarsus nearly vertical is not found in any Johnstonianidae known to the writer, but is found in some of the smaller Erythraeidae. Again, the setae are quite elaborately pectinate, which is also unlike the Johnstonianidae, in which the setae of the body are generally smooth and borne on elevated alveoli. The single eye is also more characteristic of certain of the Erythraeidae than the Johnstonianidae. The association of the type species with ants would also be quite unusual for the Johnstonianidae which are largely subaquatic, and are normally found only in very wet situations which would be incompatible with ant nests. In view of these considerations it is the feeling of the writer that the genus *Myrmicotrombium* does not belong in the Johnstonianidae, but rather in the Erythraeidae. A study of the chelicerae of the type species would resolve this question; unfortunately Womersley did not describe these. The type species, *Myrmicotrombium brevicristatum* Womersley 1934 is known from a single

specimen collected at Glen Osmond, South Australia. The type is in the South Australian Museum.

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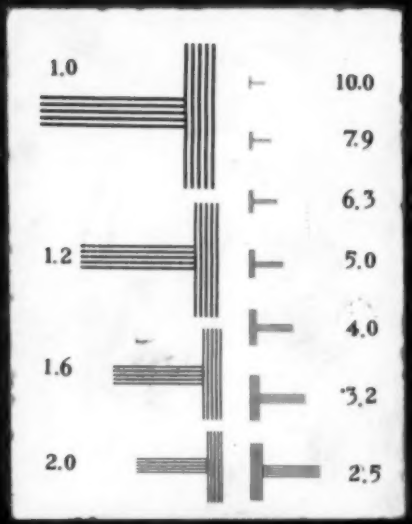

100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and $7.9 \times 5 = 39.5$ lines per millimeter recorded satisfactorily. $10.0 \times 5 = 50$ lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.